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Rogue River
Boating Safety and Conflicts Study

June 1995

Prepared for:

USDI - Bureau of Land Management
Medford District Office
Medford, Oregon

and

Oregon State Marine Board
Salem, Oregon

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Boating Safety and Conflict Study

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Prepared for:

Cosponsoring Agencies

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Medford, OR

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Oregon State Marine Board
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DISCLAIMER

The opinions, findings, conclusion, or recommendations expressed in this report are those of the authors and do not necessarily reflect the views of the cosponsoring agencies nor does mention of trade names or commercial products constitute endorsement or recommendation for use by the federal government.

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The collective leadership and agency involvement continued throughout the life of the boating safety and conflict study by agency representative involvement as technical resources to the study contractor and the public Focus Group.

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EXECUTIVE SUMMARY

This study was designed as a technical background evaluation of recreational boating safety risks and conflicts as part of a river recreation management planning effort. The objective was to develop a quantitative assessment of boating safety and conflicts in two separate reaches of the Rogue River and to develop safety risk probability estimates. The primary boating safety and conflict concern was the nature of the interaction between jetboating activities and a wide range of non-motorized river recreational activities. The assessment of safety risks and conflicts was developed using a two part approach; 1) an assessment of the physical nature of the channel and hydraulic conditions, the operational characteristics of various craft, and user patterns; and 2) the qualitative and subjective perception of safety risk situations in the Study Area as held by members of a Focus Group of recreation users.

To realize the study objectives a risk probability modeling approach was developed for quantifying the level of boating safety risks and conflicts. The modeling approach was basically Bayesian in nature. The estimates of safety risk exposure and conflict probabilities were based on what was known, measurable, and observable about jetboat operations and craft characteristics, observed and measured channel/hydraulic conditions, observed and measured floatcraft use patterns at specific locations of potential safety risks, assumptions about craft operator decision making, definitions of potential safety risk situation and acceptable craft separation standards, spatial and temporal distribution models of jetboat and floatcraft activity throughout the recreational day, and seasonal jetboat and floatcraft use levels. The approach had two basic modeling components. First, the "inherent safety risks" of specific sites of potential safety risk were developed using a fault-tree assessment approach. Second, probability estimates of overall safety risk exposure and conflicts were assessed by combining the inherent safety risk at the various specific sites with recreational use patterns.

The risk modeling approach included two major assumptions: when assessing inherent safety risks, whenever possible jetboat operators always avoided potential safety risk situations by modifying operations; and, best skills and judgement were always applied in this effort. As a result the inherent safety risk, as used here, addressed only those potential accident situations that were unavoidable given the best of operational and navigational circumstances. This excluded all potential accidents that may result from mechanical failure, poor operator skill and judgement, and operator error. The inherent safety risks therefore, reflect potential accident situations that were idiosyncratic to the channel conditions and craft characteristics in the study area.

With a Bayesian model approach safety risk and conflict probabilities can be estimated for the study area under any number of modified scenarios. Modifications could include different jetboat craft characteristics and daily trip schedules, different channel conditions, different standards for acceptable safety risk conditions, different recreational management approaches, different floatcraft use levels and demand, and changed daily spatial and temporal floatcraft distribution patterns. This modeling flexibility provides the recreation management agencies the option to evaluate the potential safety risk and conflict implications of various possible recreation management actions. Because the approach is suited for estimating relative safety risk exposure and conflicts for many different recreational scenarios, it can serve as a management tool when addressing issues like recreation management and acceptable safety risks.

Using this approach, boating safety and conflict issues on the Hellgate Study Reach portion of the study area were modeled using the channel conditions, jetboat and floatcraft characteristics, and behavior patterns observed in 1992. Annual uses in the Hellgate Study Reach are estimated to include about 70,000 visitors on about 800 scheduled commercial jetboat trips, several hundred trips by non-commercial jetboats, about 36,000 visitors using a variety of floatcraft, and about 9,000 wading and bank angler visitors. Sixteen sites were identified that had channel/hydraulic and line of sight limitations that presented possible safety risk conditions. Fault-tree assessments indicated that under the best of operational and navigational circumstances, at 14 of these sites, situations existed where safe craft separation thresholds could be inadvertently exceeded and accident situations were possible. This means that even assuming the best operator skills and judgement, channel conditions at these specific sites were such that not all potential accident situations were avoidable. The average inherent safety risk probability at these 14 sites was .159 or, on average at each of the sites, about 16 out of 100 jetboat runs could result in potential inadvertent accidents when floatcraft are at these sites and not observable by the jetboat operator. Contrary to user perception, the assessment indicated that the average inherent safety risk probabilities of the lower gradient riffles in the Scenic Section were about twice those of the steeper gradient rapids of the Whitewater Section (.223 v. .124). This assessment also showed that

the inherent safety risks were 37% greater under lower flow conditions due to more limited jetboat operational flexibility and narrower channel conditions, and that the inherent safety risks for upstream jetboat operations were 128% and 517% greater than downstream operations (depending of flow conditions) due primarily to line of sight thresholds that do not improve with wait times at these specific sites.

Different safety risk estimates resulted when the inherent safety risk results were combined with jetboat and floatcraft spatial and temporal distribution models representing 1992 conditions. With respect to the two sections of the Hellgate Study Reach, adding the craft distribution models to the inherent safety risks reversed the safety risk probabilities. Although there were only two daily commercial jetboat trips scheduled through the Whitewater Section the seasonal safety risk exposure was estimated to be 18% and 105% greater (depending on flow condition) for this portion of the reach than the 5 or 6 daily commercial jetboat trips combined in the Scenic Section. This was primarily due to both a larger number of sites with potential safety risks (5 v. 9) and significantly greater levels of floatcraft use in the Whitewater Section (10% v. 90%). With respect to jetboat trip itinerary schedules, the estimated safety risks associated with the two daily Whitewater commercial jetboat trips were 127% and 267% greater (depending of flow condition) than the four daily Scenic Section trips combined. The two daily Whitewater commercial jetboat trips accounted for between about 70 and 80% of the total seasonal safety risk exposure of the entire commercial jetboat seasonal schedule. For the entire seasonal commercial jetboat schedule, low flow conditions present about 30% greater levels of safety risk exposure than do high flow conditions.

For the Hellgate Study Reach the risk assessment resulted in the following general conclusions. Channel/hydraulic characteristics, craft characteristics, and user patterns were such that it was not possible for potential accident situations to be avoided and the development of those situations were outside the control of craft operators. Many of the potential accidents situations could degrade into actual accidents, and these accidents could have major consequences. The actual accident scenarios would be a function of the particular distribution of craft in the potential accident situations, their speeds, and the actions of operators. These results indicated that the existing record of jetboat related incidents and accidents were not reflective of the nature and potential severity of possible future accidents. Due to the present user activity levels, the probabilities for a major accident are very small, however, given the number of jetboat runs through the study reach during a full season, major accidents appear inevitable. The assessment did not address issues of acceptable levels of safety risk.

Limited data on user patterns prevented the appropriate application of the boating safety and conflict modeling approach, as was developed for this study, on the Gold Hill Study Reach. However, preliminary fault-tree analyses indicated that unavoidable potential accident situations were also possible on this study reach but fewer locations of potential accidents were identified and channel, craft, and user pattern characteristics would most likely result in lower probabilities of safety risk exposure and result in less severe accidents than were possible on the Hellgate Study Reach.

Safety risk and conflict reduction recommendations were developed by the members of a Focus Group from on-river experience and by WRC-Environmental from on-river observations and model assessment results. These recommendations were evaluated for potential implications to safety risk exposure, safety risk-related conflicts, user activity types, and to recreation management.

I: INTRODUCTION

A: Study Purpose

The river recreational activity types present in the Rogue River Boating Safety and Conflict Study Area include a broad spectrum of uses. These activities include jetboating, rafting and floating in a variety of craft types and sizes, driftboating, boat, bank and bed angling, and wading and swimming. Jetboats (JB) include non-commercial uses of small craft used for angling and/or recreational boating (pvt-JBs) and larger commercial motorized tour boats (MTBs) which provide river tours for 20-80 paying passengers.

Since the early to mid-1980s the level of recreational uses in the study reaches have notably increased. Floatcraft (FC), driftboat, wading and swimming, MTB, and pvt-JB, as well as other uses have all increased. From the early 1980s the annual number of MTB passengers has grown from about 19,000 to about 70,000 and since the mid-1980s the number of individual MTB craft trips has grown from about 330 to about 760 annually (Walker and Austermuehle 1994). With increased uses in all activity types the frequency of encounters between JBs and non-motorized river recreationists has increased dramatically.

Increasing interaction between motorized and non-motorized river recreationists has lead to a general sense of recreational resource value degradation, on-river conflicts between activity types, and possible boating safety issues. These concerns have been primarily expressed by non-motorized users. The safety concerns are in part generated by the disparity between the motorized and non-motorized craft and other bank, bed and water use recreationists in terms of size, speed, control over safety circumstances, and consequences of contact and near contact situations.

The Bureau of Land Management (BLM) has undertaken the revision of its Hellgate Recreational Area Management Plan (RAMP). In the scoping process for that planning effort boating conflicts and boating safety were identified as important issues by the public and other local, state and federal agencies. Public concern had been expressed over the increasing number of river users and the intermingling of diverse types and sizes of watercraft on the Rogue River. These concerns involved both perceived and actual threats to personal safety as well as competition between users for space or position on the river, resulting in the potential for conflict between users.

As part of the RAMP effort BLM identified the need for a background report on boating safety and conflict (BS/C) issues to target specifically the interaction of motorized and non-motorized activities and users. The goals of the BS/C background report included: 1) determining the extent to which BS/C needs to be addresses in the revised RAMP; 2) identifying and evaluating present and potential BS/C conditions and/or problems; 3) identifying and assessing attitudes, perceptions and tolerance of users for BS/C conditions; and 4) developing recommendations for resolving BS/C issues.

This Rogue River Boating Safety and Conflict Study (BS/C Study) is the technical background paper on these motorized/non-motorized recreational issues for the BLM's on-going RAMP process. It was designed to take a quantitative approach to assessing motorized/non-motorized BS/C issues in the study area and to develop a probability model for safety risk. It was intended to provide the basis for distinguishing "real" accident potential from "perceptions of risk", to provide the basis for separating safety risk-related conflicts from resource value conflicts, to assess the potential for safety risks and safety risk-related conflicts given the activity mix, user patterns, and channel conditions in the study area, and to provide safety risk reducing recommendations.

The design of the BS/C Study was intended to combine two semi-discrete approaches; a risk analysis approach, and a user perception approach. The risk analysis was designed to evaluate measurable parameters that may determine BS/C concerns. These risk assessment parameters included craft operational characteristics, user patterns, and channel/hydraulic characteristics. These measurable parameters were to be used to develop risk variables and to develop a probability model of safety risks.

The user perception approach was intended to provide user input to the BS/C Study approach, input on safety risk concerns, and reaction to the risk analysis results. A Focus Group (FG) composed of members from the various user activity groups of the river was used to provide user perception input. Besides providing advice and input to the risk analysis the FG members were to identify safety margins for acceptable user risk, and to provide input on potential BS/C risk management approaches.

B: Study Area

The study area of the BS/S Study include two separate reaches of the Rogue River in southwestern Oregon. These two reaches are on a portion of the Rogue River locally known as the "Middle Rogue" which is a section between 68 and 125 miles above the mouth of the Rogue River at Gold Beach (see Figure 1). Each of the reaches have similar user activity types and potentially similar BS/C issues but due to radically different use levels they were evaluated independently. In this BS/C Study river locations are given in river miles (RM) as measured from the upstream end of each study reach along the center line of the active channel.

1) Hellgate Study Reach:

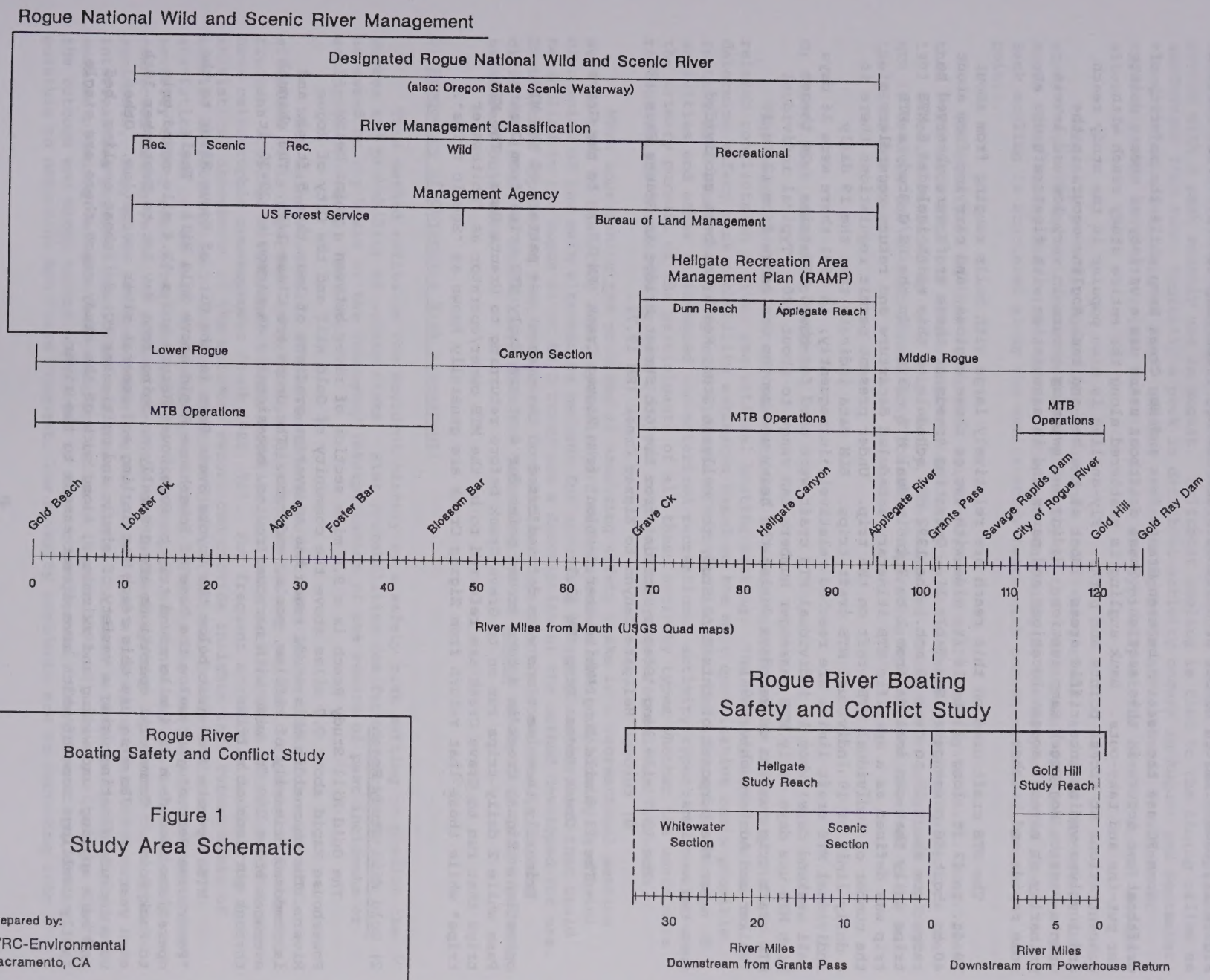
The Hellgate Study Reach is a 33.3 mile section of river between the City of Grants Pass and the Grave Creek boat ramp. The lower 26.7 miles of this study reach, from the mouth of the Applegate River to the Grave Creek boat ramp, is part of the designated Rogue National Wild and Scenic River and is the subject of BLM's RAMP process.

The Hellgate Study Reach has an average gradient of about 8+ ft/mi. and is characterized by riffle/run/pool channel characteristics with occasional rapids that could be categorized as Class II/III- rapids. The river averages about 300 ft. wide but usable routes for powerboats through some riffle and rapids narrow to 20-40 ft. wide. There is one location, Sentinel Rock, where the portion of the river used be all activity types narrows to less than 40 ft. and is bounded by near vertical bedrock walls. In the upper 18.9 miles to the Hog Creek Ramp, the river has a gradient of about 7 ft/mi. and channel averages about 400 ft. in width. The channel is characterized by a riffle/run/pool configuration. In the lower 14.5 miles, from the Hog Creek Ramp and the top of Hellgate Riffle through to Grave Creek the river has a gradient of about 10 ft/mi. and averages about 200 ft. in width. In this section the channel is characterized by a rapid/run/pool configuration. The rapids are structured by bedrock controls.

MTBs operate from Grants Pass to below Hellgate Canyon and return (a 41 mile round trip) and to Grave Creek and return (a 67 mile round trip). By permit regulation, the season of commercial MTB operations presently extends from May 1st to September 30th each year. Pvt-JBs also use this reach for angling and general on-river recreation. Other uses include floating using a variety of single and multi-user craft, driftboat angling, bank angling, and wading and swimming. Along the upstream most four miles of the study reach there are many single family dwellings, some of which have direct assess to the river. The rest of the study reach has scattered cabins and houses and open space created through easement purchases by the BLM for purposes of scenic and recreational resource management.

Total annual recreation use levels in 1991 were estimated to include about 36,000 visitors in various FC and about 73,000 visitors in MTBs (Austermuehle 1992). Most of this use occurs in the May to September period with a peak monthly use in August. Driftboat angling, with another 8,000 annual visits, is tied to the timing of anadromous fish runs; typically a peak in driftboat activity occurs in August and September timed with the fall Chinook runs. Wading and swimming occur at scattered locations at typically very low use levels. These locations are typically at the several county park access sites.

Generally pvt-JBs are used between Grants Pass and Zigzag Creek (RM 19.7) with a few using the entire study reach; most use is between Grants Pass and Robertson Bridge (RM 14.8). General FC activity is mostly between the Hog Creek Ramp and Grave Creek using a variety of access points for put-ins and take-outs. Visitor use information for 1991 indicated that 90% of the FC use occurs in this section (ibid). 1992 WRC field work



Rogue River
Boating Safety and Conflict Study

Figure 1

Study Area Schematic

Prepared by:

WRC-Environmental
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indicated that significant FC put-ins occur at most of the access locations even as far downstream as the Argo site (RM 31.4); many of the FC launches in the lower 5 miles were trips routing into the whitewater of the "Canyon Section" resource below Grave Creek (See Figure 1). Some limited number of driftboats use the Hog Creek Ramp to Grave Creek section as well.

Some FC use the section between Grants Pass and Hog Creek Ramp while the majority of driftboat use occurs in this section. These driftboat users use a variety of access points for put-ins and take-outs. Bank angling is scattered along the entire study reach with concentrations at access points and parks. Fly-angling is also popular in the study reach and involves wading into riffle areas. Most of the bed and bank angling occurs in the Grants Pass to Hog Creek Ramp section. Wading and swimming occurs in very low use levels primarily at several access locations and parks and in association with floatcraft use at some rapids and beaches.

The MTB craft used on this reach are relatively large with hulls ranging from about 30 ft. to 42 ft. long, 11 to 14 ft. wide with two or three engines, and carrying from about 40 to about 80 passengers (See Table 1). Operating speeds of these craft were observed to range from about 25 to over 40 mph. The 1992 MTB schedule on this reach included 6 MTB trips daily that can include from 1 to 7 individual MTB craft. In the BS/C Study a MTB trip was defined as a specific MTB itinerary scheduled departure and return regardless of the number of individual MTB craft on the trip. Under present permit regulations there is a daily limit of 19 individual MTB craft trips. BLM data indicate that the 19 daily individual MTB craft limits are reached relatively infrequently; in 1991 there were 16 days (all weekend days) when 19 individual MTB craft were used for the 6 MTB trips. On these high MTB use days daily MTB passenger numbers can range to about 920. Typical individual MTB craft trip numbers on weekdays during the heavy use months can range from 12 to 18 (Walker and Austermuehle 1994).

For the purposes of this BS/C Study the Hellgate Study Reach has been subdivided into two sections:

- The 19.7 mile long "Scenic Section" from the 6th Street Bridge in Grants Pass (RM 0) through Hellgate Canyon to Zigzag Creek (RM 19.7).

- The 13.6 mile long "Whitewater Section" from Zigzag Creek (RM 19.7) to the Grave Creek Access Ramp (RM 33.3).

Primarily these sections were defined based on the present use pattern of the MTB operation. Zigzag Creek is a turn around point for 4 of the daily MTB trips from Grants Pass while 2 daily trips run on to Grave Creek before returning to Grants Pass. The MTB trips that run to Grave Creek are referred to by the MTB owner/operator as "Whitewater trips" while those that return from Zigzag Creek are generally known as "Scenic trips".

2) Gold Hill Study Reach:

The Gold Hill Study Reach is a 9.6 mile section of river between a point below Powerhouse Rapid about 0.7 miles above the community of Gold Hill and the City of Rogue River. The channel in this study reach has an average gradient of less than 5 ft/mi. and is composed primarily of riffles, pools, and runs. The drops are Class I/II. The channel averages about 200 ft. wide with narrower routes, occasionally as narrow as 20-30 ft., through portions of riffles.

MTBs operate from just below the Coyote Evans Ramp in the City of Rogue River to the "Powerhouse Return" just below the base of Powerhouse Rapid above Gold Hill. Their operations include a 19.4 mile round trip to Powerhouse Return and a 12.4 mile round trip to Rock Point. Commercial operations are generally on-going from May 1st to September 30th each year. Pvt-JBs also use this reach for angling and general river recreation. Other uses include floating using a variety of single and multi-user FC, driftboat angling, bed and bank angling, and wading and swimming. Along much of the study reach there are single family dwellings some of which have direct assess to the river.

Total recreation use levels in this study reach are unknown with no agency having general recreation management responsibilities. Based on the field work undertaken in this BS/C Study use on this reach was estimated to be less than 10% of that in the Hellgate Study Reach. Like the Hellgate Study Reach most of this use occurs in the May-September period with a peak monthly use in August. Driftboat angling is tied to the timing of anadromous fish runs; typically a peak in driftboat activity occurs in August and September timed with the fall Chinook runs. Wading and swimming occur at scattered locations at typically very low use levels. These locations are typically at the several formal access sites.

Generally pvt-JBs, both high performance and fishing sleds, are used throughout the study reach, FC and driftboats are used primarily in the 7 mile reach from Gold Hill to the Rogue River Valley Park with a small percentage continuing to the City of Rogue River. Bank angling is scattered along the entire study reach with concentrations at access points.

The MTBs used on this reach were relatively small craft ranging to 30 ft. long, less than 9 ft. wide with one or two engines, and carry up to 30 passengers (See Table 1). The 1992 schedule included up to 4 trips daily, most composed of one craft; sometimes a second MTB is used on the evening Dinner trip schedule. Operating speeds were observed to be in the 15-25 mph range.

C: Safety Risk Assessment Methods

The Rogue River BS/C Study was intended to assess safety risks and safety risk-related conflicts in a river recreational boating setting. The primary objective was to determine safety risk probability estimates based on the most quantitative basis possible. In this BS/C Study the safety risk elements of concern included the interaction between JB activities and other water-based non-motorized recreational activity types. Recreation was the primary pursuit of the participants of all these activity types whether the users were recreationists themselves or were involved in providing guided recreational services.

When approaching the problems of assessing safety risks in a recreational setting such as that of the study area, several basic methods can be used. Following is a brief discussion of the main alternative methods for assessing potential safety risk that could be applied in the Rogue River BS/C Study and a description of the method developed for use. Each method approaches risk assessment from different perspectives and result in very different levels of reliability when the determination of actual safety risk is the primary assessment objective.

1) Frequency or Objective Risk Assessment:

This method relies on the accident history of a safety risk setting to predict the degree and probability of safety risks. Risk probabilities for future accidents are assessed on the basis of the frequency interpretation of the record of past incidents or accidents (Spjotvoll 1987, 13).

When using statistics of past accidents to estimate future risks for a particular situation it is important to maintain a distinction between two basic classes of accidents; frequent accident situations of minor severity, and very rare accident situations that may have catastrophic consequences (Wenk 1986, 56). For frequent accident situations the statistical assessment of the accident record can provide insights into future risks of similar characteristics. For rare event accident situations, however, historical statistics can not be used to assess future risks. This is the case because frequent, low severity safety risk situations and rare, catastrophic accidents may not be genetically connected and there may be unknown threshold and feedback systems separating these types of accidents. Many major accident scenarios are a result of a cascading chain of events interrelating physical conditions and human actions. In these situations operator errors such as planning failures and execution failures (Reason 1990, 8) can significantly effect the outcome and minor errors could lead to major consequences. Therefore it may not be possible to determine how close frequent, low severity accidents are to degrading into

major accidents of severe proportions. If true the probabilities of frequent, low severity and rare, major accidents would not be statistically related. In some situations it is possible that the rare and catastrophic accident has yet to occur when the risk assessment is undertaken (Wenk 1986, 56).

When considering these rare accident events with potentially catastrophic outcomes alternative assessment methods must be used. These may include fault-tree analysis and accident scenario development. With these more Bayesian techniques, the potential accidents situations can be dissected and assessed for possible safety risks and probabilities (ibid., 56).

Safety risks can be underestimated if historical incident report statistics are used to extrapolate a limited data base or a data base on frequent, low severity accidents, to estimations of rare, catastrophic accidents. This situation in a commercial maritime setting was exemplified by a safety assessment of the Washington State ferry system in Puget Sound. In 1982 Edward Wenk (Wenk 1986; Grabowski 1993) conducted an extensive safety analysis of maritime safety in that region and concluded that the historical record of minor ferry accidents did not adequately represent the potential for rare, catastrophic accidents. Using an accident scenario approach it was demonstrated that in spite of an accident record limited to minor incidents, severe accident scenarios were possible, and that accidents could lead to catastrophic situations. In response to that assessment "...the US Coast Guard contended that (1) casualty statistics confirmed that bad ferry accidents were rare; (2) should a vessel be sinking, rescue craft were not far away; and (3) in any event, it was safer for ferry passengers to remain on board, since even if the boat were cut in half both halves would float." (Wenk 1986, 56) In general the probabilities for major catastrophic ferry accidents were discounted by responsible agencies. Subsequent serious ferry boat accidents proved the accident scenario conclusion, as developed by Wenk, was fundamentally correct.

In the Hellgate Study Reach of the study area, the US Coast Guard (USCG) has recently reached similar conclusions as to the safety of MTB operations.

> "The USCG has been involved in the regulations of the MTB industry on the Rogue River since 1975. During this period, the vessels have been maintained or brought within the standards of the USCG. The mariners (i.e., MTB operators) have been held to the same standards of enforcement which other portions of the marine industry have been held. The casualty record of the industry does not indicate a pattern of dangerous operations. Additionally, there are regulations in place to remove vessels or mariners if they are determined to pose a threat to marine safety. Based upon the casualty records and existing regulations this industry is considered a safe marine operation." (Walker and Austermuehle 1994, 35)

During the course of this BS/C Study the official records of several reported incident and accident situations involving MTBs and pvt-JBs were reviewed (See Chapter II). While no deaths or serious injuries were reported as a result of JB operations in the study area, the record indicates that accidents and near accidents have occurred and that it is possible that only slightly changed circumstances in those incidents could have lead to very serious outcomes including serious injury or loss of life. Without regard to the cause or fault of the reported accidents it appeared from a review of the record and the review of site conditions in the study area that rare and catastrophic accidents are possible in this recreation setting. Therefore, the accident record does not support the above USCG conclusion as specifically applied to the Rogue River BS/C Study Area.

A statistical assessment of risk based on the historical safety risk record was not considered a reliable approach when faced with the implications that the accident record may only reflect some of the more frequent, low magnitude incidents. These incidents would not resolve the possibilities of, nor circumstances for, more serious accident scenarios.

2) Perception or Subjective Risk Assessment:

This method relies on the subjective perceptions of safety risks of the individuals involved or potentially involved in the safety risk situation. This method can use a four

stage process to formulate subjective risks: 1) the subjects define what they consider dangerous situations (hazards); 2) the subjects develop a scale on which to differentiate between hazards; 3) the subjects rate the hazards on the scale; and, 4) factor or cluster analyses are used on the results to determine the factors that subjects are using to assess hazards (Hale 1987, 69-70).

Unlike many subjective risk assessments, the situation in the Rogue River BS/C Study involved subjects (recreationists) from a variety of recreational activity types engaged in an interactive safety risk situation. That is, the potential safety risks under consideration in this BS/C Study were those associated with the use and activity pattern interaction of conflicting activity types; JBs vs. non-motorized activities. These users did not represent a range of users exposed to the same risk situation who may have different perceptions of the nature and severity of the danger and the possibility of dangerous situations occurring. Rather, when considering the inherently different nature of JB and non-motorized activities, if they were involved in the same safety risk situation or incident, the activity type users would be exposed to very different safety risk environments. Therefore, in a particular safety risk situation or incident, when faced with different safety risk environments the participants in these JB and non-motorized activities would be expected to have very different perceptions of risk probability and severity. These inherent differences can result in different perceptions among the participants of risk probability, risk severity, and margins of acceptable risk. Given these potentially inherent differences in perceived risks it was unlikely that useful agreements could be reached among the various user activity types on the safety risk situation in the study area. In addition the Focus Group (FG), which was used to provide representative user input to the study process, was composed of an exceedingly small number of users (13) and could not be expected to be statistically reflective of the users and safety risk perceptions of the recreationist's in the study area (over 130,000 annually).

The following is a list of some of the perception based safety risk issues that made the application of this method inappropriate for the situation in the Rogue River study area;

- The perception of safety risks depends on the degree to which the potential hazard or its occurrence is under the control of the subject. Given the size and speed of JBs, all important safety risk decisions are made by JB operators. The perceived risk of a situation may be greater for non-motorized recreationists because they are not in control of potential safety risk encounters. Those who believe themselves knowledgeable and in control of a potentially dangerous situation, even when the magnitudes are great, may show less concern than may be warranted (Hale 1987, 75). The relationship between the perceived risks of JB operators and the non-commercial FC operator members of the FG, which were demonstrated throughout the FG process, reflect this difference in perception.

- The placement of trust or the transfer of responsibility to others can reduce the subject's level of safety risk concern (ibid., 75-6). When commercial passengers in either rafts under the care of a raft guide or in MTBs, the perceived level of safety risks may be lessened as these subjects may tend to assign the responsibility for considering safety risks and determining the appropriate action to the craft operator. They may tend to interpret safety risks through the actions of the guides and assume that most safety risk circumstances which they may observe are normal and considered acceptable. As a result passengers of commercial craft could be expected to underrate the actual degree of safety risks.

- The difference between voluntary and compulsory activities, and by extension, the degree to which a subject exercises choice to enter a situation of safety risk exposure may lead to different perceptions of safety risk (ibid., 76). In the study area there may be several dimensions to this issue. FC and other non-motorized recreationists may have knowledge of the safety risks associated with their own activities and determine that the safety risks of the activity are less significant than the values gained. When that activity includes encountering JBs on the river and an increase in the level of perceived safety risks occurs due to the actions (or the presence) of other

activities, this additional risk is accompanied by no increase in resource values. It may also be considered as a compulsory risk element within their own voluntary activity. A second dimension may be found in particular on-river situations in which non-motorized users may be required to deal with the safety risks associated with the presence and operations of a JB in the process of their own on-going non-motorized activity. The level of perceived safety risk may be amplified if the non-motorized user is involuntarily exposed to JBs in an area of complex hydraulics and channel constriction and is unsure of the actions to be taken by the JB operator. These elements of involuntary risk may lead to overrating the actual degree of safety risks.

- The perceived degree of potential accident severity can have a strong bearing on the perception of risk (ibid., 78). In the study area the MTBs are relatively large (25-40 ft. long) and fast (25-45 mph). When these craft encounter non-motorized recreationists these other users can have the perceived sense that an accident would result in major consequences to them. Conversely passengers and operators of JBs may sense that an accident would probably result in little significant consequences. These relative perceptions can result in non-motorized craft users overrating safety risk while JB users may underrate safety risks.

- The familiarity with the risk situation can decrease the perception of safety risks (ibid., 77). MTB operators run the various reaches of the study area as many as several times each day. In that process they may run a MTB through any of the identified potential safety risk areas hundreds of times each year. Also the commercial FC operators in the study area have extensive on-river familiarity with the areas of potential safety risk and have dealt with many encounters with JBs. These users have repeated experiences with encounters and with operating in the various potential safety risk areas. The vast majority of these experiences have not included safety risk problems nor, in large measure, recognition of near-accident circumstances. With these two factors, familiarity with the potential safety risk situation and the perception of repeated non-risk outcomes, experienced users may underrate the safety risk possibilities. Conversely those without familiarity with the safety risk situation may easily envision the possible safety risk scenarios and overrate the safety risk possibilities. These users would include the many single trip users who may be MTB passengers, clients of commercial raft operations, and non-commercial users. Differing safety risk perceptions due to this familiarity aspect were evident throughout the FG meetings.

- For different groups of users involved in a mutually related safety risk situation to agree on an acceptable level of perceived risk they must perceive some degree of risk equity (Doderlein 1987, 6-7; Hale 1987, 74-5). The concept of risk equity may include all of the individual perception factors listed above as well as factors that relate the perception of risk and the perception of values gained by engaging in the safety risk activity. In the case of some FG members this issue also included economic factors as their jobs and/or businesses were directly or indirectly dependent on the presence of users. With this issue in mind the safety risk factors for these members could include an economic overlay which could be expected to increase the values received for any given amount of risk. This may result in higher levels of perceived acceptable risk and a different risk/value relationship. Risk equity also involves the balance between cause and effect of risks between the various activities. This relates to the balance of perceived risk factors among the various user activity types involved in a safety risk situation. In the study area, perceived risk factors such as control, severity, compulsory involvement, etc. resulted in a distinct difference in perceived risk equity between the JB and non-motorized users. Differences in risk equity were evident throughout the FG process. Risk equity among the various user activity types needs to be addressed if recreation management is to be based on user perceptions of safety risks. Equity needs to address both the risk/value trade-off for each activity type and the balance in all the risk elements (some of which are addressed above) between the user activity types.

Through the Rogue River BS/C Study and the FG process all of the major user or subject perception factors were evident. Opinions and perceptions of safety risk varied among the members of the FG based on: 1) the relative level of control with JB operators expressing less concern for present safety than others; 2) the relative level of voluntary involvement with non-commercial, non-motorized users expressing higher levels of safety risk concern under present circumstances than JB operators; 3) the relative level of possible accident severity with non-motorized users expressing greater concern for safety risks than JB users; 4) the relative level of familiarity with those daily commercial users, both MTB operators and commercial raft operators, expressing less concern for safety risks than the non-commercial, more infrequent users; and, 5) the relative level of economic dependence on the risk environment with those involved in commercial activities and tourism expressing less concern with the present level of safety risk than the non-commercial users.

In a review of general risk research, Doderlein (1987, 6) identified three broad categories of safety risk issues that should be considered when dealing with risk management. These issues are very applicable in a recreational setting such as the Rogue River study area where conflicting users or activity types are creating the potential safety risks under consideration. They are also very applicable and appropriate to the management of the safety risk environment in the study area. These issues include risk democracy (risks distributed evenly over the user population), risk-cost effectiveness (risk reduction dollars spent where the greatest reduction of risk is realized), and risk-benefit equity (risks and benefits or values distributed evenly over the user population). Given these issues and the extremely divergent perception positions among the user activity types in the study area it was unlikely that subjective perceptions of safety risks alone could result in a useful resolution. This would be particularly true with regard to risk democracy and risk-benefit equity, and also risk-cost effectiveness should user perceptions of risk-benefit equity be at odds with managing agency allocation of risk reduction effort and expenditures.

3) Bayesian Risk Assessment:

This method is designed to develop estimates of risk probabilities by combining incident frequency, subject perceptions of safety risks, and the application of all known information on the risk situation. This method can generate risk probability estimates by developing a model of the accident environment based on the physical and behavioral nature of the setting. The modeling approach can use fault-tree, accident anatomy, or worst case scenario evaluation techniques. Risk probabilities can be further resolved by using subject perception evaluation of safety risk probabilities and severity. The Bayesian method can develop estimates of probability that would be unknown using the frequency method alone (Spjotvoll 1987, 17).

A Bayesian model approach was developed for the Rogue River BS/C Study. The primary assessment elements of the Bayesian model included: 1) the definition of safety risk issues of concern using user (FG) perception; 2) the development of safety risk thresholds that would identify a safety risk problem using user (FG) perception; 3) the identification of JB craft operational limitations using on-river measurements of water depth and line of sight limitations; 4) the estimation of MTB stopping distances using stop tests; 5) the definition of MTB and FC operational rules based on user (FG) input and conservative assessment bias; 6) the estimation of inherent safety risk probabilities at specific sites of concern using a fault-tree risk assessment approach; and, 7) the estimation of total potential safety risks using temporal and spatial models of MTB and FC use patterns.

Similar to any risk probability model of an actual setting, the results of the Rogue River BS/C Study should be strictly regarded as an approximation of the risk environment and reviewers should be aware of false precision in the risk probability results (Hovden 1987, 167). Conversely, in spite of false precision and approximation concerns, model results can be highly accurate if the results are viewed in relative terms. That is the assignment of a specific quantitative probability for a specific situation may prove numerically inaccurate in itself but in the context of other situations and sets of circumstances may provide a very accurate relative measure of risk.

As presented in the specific chapters of this report many elements of the risk assessment and model were based on operational assumptions and estimates of physical parameters. Different physical parameters could alter the risk probability results as would the use of different criteria in identifying safety risk situations. In addition conservative assessment bias was used to limit safety risk concerns to only those that could not be avoided by normal operational adjustments. This approach eliminates from consideration all potential accidents and safety risks that could result from operator error or skill and/or judgement shortcomings.

Bayesian safety risk models and model outputs should also be tested for reasonability. This test should include: 1) a review by the subjects that provided the perception inputs and assisted in developing threshold criteria to determine if the model results adequately reflect their perception of the total risk setting; 2) a review of the physical and operational nature of the actual safety risk setting to determine if it is adequately represented by the sequence of modeling steps and assumptions; and, 3) a review of the model predictions of safety risk probabilities to determine if the results are reasonable within the context of the existing accident and incident record.

With the addition of new information and more refined subject perception input these types of models can be improved to better reflect the existing safety risk environment. They can also be modified to accommodate future changes in the risk environment that may occur through either management decisions, changing recreational uses, or changing physical conditions in the channel. If the review of the model and model outputs leads to the conclusions that the model is unreasonable or if further resolution is desired, the Bayesian model approach allows for the adjustment of various parameters, criteria, and operational assumptions. Adjustments and model iterations can be repeated until the risks probability outputs and the criteria inputs achieve an acceptable level of comfort with the subjects. Also this modeling approach allows modifications of parameters, criteria, assumptions, and physical characteristics to accommodate changing user patters, changing craft operational characteristics, changing channel conditions, changing perceptions of safety risk, and simply new or more specific information. With an operating Bayesian model that adequately reflects the safety risk setting, various risk management options can be evaluated for effectiveness and efficacy by modifying the appropriate modeling conditions and parameters etc.

D: Study Approach

Three entities were involved in the BS/C Study: the contractor, WRC-Environmental, government agencies, and members of the public. WRC-Environmental conducted the field work, collected the basic information that was used in the BS/C Study, developed the various modeling and BS/C assessment procedures, conducted the analyses, and managed the Focus Group meetings. Six cosponsoring agencies were involved in the BS/C Study and members of those agencies identified boating safety as an issue, developed overall study objectives, funded the study, provided technical input to the Focus Group during the meetings, reviewed various written products developed by WRC during the course of the study, approved the evolution of the BS/C Study and safety risk modeling approach, and participated in field trips. A Focus Group, composed of representatives of 10 user activity types on the Hellgate Study Reach, provided input to WRC on the basic safety problems, parameters and criteria for safety risk, reviewed and commented on the modeling approaches developed by WRC, and provided recommendations for resolving BS/C issues.

1) Cosponsoring Agencies:

Cosponsoring agency staff representatives to the Focus Group meetings included:

Bureau of Land Management;
Mike Walker (Rogue River Planner)
Eric Schoblom (Associate Manager, Rogue River program)

Jackson County Sheriff's Office;
Ron Oacks (Marine Deputy)
Mike Lougheed (Marine Deputy), alternate

Josephine County Sheriff's Office;
Jim Berning, 1992-1993 (Marine Deputy)
Ernie Fields, 1994 (Marine Deputy)

Oregon State Marine Board;
Wayne Shuyler (Assistant Director)

Oregon State Police;
Jack Baker (Senior Trooper)
Tim Barouletos, alternate

US Coast Guard;
Lt. Luke Hardin (Chief, Investigations Dept., Marine Safety Office)

2) Focus Group:

The Focus Group (FG), designed to assist in the BS/C Study was composed of a group of Hellgate Study Reach users from various user sectors and activity types. As part of the study process, the function of the FG was to provide several different forms of input, including: 1) input and reaction to the quantitative safety risk assessment and safety modeling approaches developed by WRC-Environmental through the study period; 2) input on the safety margins needed for an acceptable amount of user risk; and 3) input on potential management approaches for improving safety and reducing risks to an acceptable level.

The various FG members were selected by the cosponsoring agency representatives as knowledgeable representatives of user sectors and activity types in the Hellgate Study Reach. Each of the FG members was to provide input as individuals from, not as representatives of, the user sectors or activity types. The members were asked to act and respond as individual users with individual perceptions of safety risks and not to attempt to represent the opinions and perceptions of the user sectors and activity types at large. Since the individual FG members were not representatives of, nor envois from, the various user and interest groups they were not expected, nor empowered, to represent the interests of the user and interest groups in negotiating compromises and concessions in the effort to reach consensus. The cosponsoring agencies did not see the need to reach agreement or consensus within the FG on any issue. It was necessary however, that the interests of all members were fairly represented and that the FG members effectively work together in addressing the BS/C issues raised, developing a range of possible solutions, and developing recommendations to resolve issues.

The FG meetings were facilitated by WRC-Environmental and attended by staff representatives of the cosponsoring agencies. These representatives were present to provide factual and policy information to the FG at the request of FG members. Outside of this aspect the cosponsoring agency representatives did not play an active role in the FG meetings.

Focus Group members:

Commercial rafting guide;
Bob Rafalovich

Commercial fishing guide;
Daniel Lyons

Private motorized boater;
Wayne Kruse

Non-motorized boater/floater;
Don Beaubien

Boat angler;
Carl Backstrom
Bill Seccombe, alternate
George Moffett, alternate
Walt Doucett, alternate

Bed and bank angler;
John Edwards

Commercial motorized tour boat operator;
Jim Baumer

Boat rental livery operator;
Don Stevens

Landowner;
Martin Bauer

Representing short term non-resident users;
Linda Beauchamp

The following is a brief content summary of each of the FG meetings:

On-River meeting, 9/21/92: At the end of the 1992 summer season members of the FG, several of the cosponsoring agency staff, and WRC staff met informally at the Riverside Inn in Grants Pass and took a MTB trip to the bottom of Hellgate Canyon and back. The purpose of the meeting/trip was to informally get acquainted, review the general purpose and function of the FG, review a portion of the study area by MTB, and to have the MTB operator provide some informal insight on the operational characteristics of MTBs, and MTB trip scheduling/itineraries. No notes were taken at this meeting.

#1) 10/28/92: The BLM Hellgate RAMP process, the Boating Safety/Conflict Study, the role of the FG in the study process, and the FG process were reviewed. FG meeting rules and procedures were discussed and resolved. Each FG member described their use of the study area and the river resources of value.

#2) 12/2/92: Additional FG meeting rules were discussed. The definition of "safety" "conflict", and "hazard" and of thresholds for "safety" were discussed. FG defined types and levels of safety risk to be addressed in the BS/C Study. The issue of "acceptable safety risk" was discussed, and the 1992 field work by WRC and the proposed safety risk modeling approach under development by WRC were reviewed. Each FG member discussed their individual safety risk and conflict concerns and issues. The "Draft River Incident Evaluation" (11/24/92), prepared by WRC was reviewed.

#3) 2/3/93: The "Draft River Incident Evaluation" (1/8/93), prepared by WRC and the Oregon State Marine Board (OSMB) incident reports (1/26/93) were reviewed. The FG process through the remaining 3 meetings was established. WRC's SOC safety assessment approach was reviewed and issues of safety conditions in specific SOCs to define safety risk situations and thresholds of acceptable conditions were discussed.

#4) 3/31/93: The SOC "Safety" model, SOC safety risk assessment, MTB trip safety risk assessment procedures, and the "Whole River Conflict Model" proposed by WRC were reviewed. There was a discussion on WRC/FG safety recommendations and how they would be presented to the cosponsoring agencies. Issues of craft separation distance thresholds, channel hydraulic turbulence, and channel configuration parameters of safety were discussed. Inaccuracy of WRC's river channel/JB operational limitations mapping was discussed.

#5) 1/25/94; WRC presented the "SOC Hazard Model"; background assumptions, MTB stopping distances, SOC Assessment procedures, several example several SOC Assessments, and the whole MTB trip risk assessment model and procedures. The WRC/JB operator meeting on the river channel/JB operational limitations and the resulting conclusions were reviewed. FG members presented initial safety recommendations.

#6) 6/21/94; WRC presented the implication results of the initial safety recommendations presented by the FG at meeting #5 as well as initial recommendations developed by WRC. The results were presented in Draft Safety Recommendation Elements - Safety Risk and Conflict Implications - Hellgate Study Reach (6/10/94;78p) and were developed using the SOC Assessment, the Safety Risk/Conflict Model and the FC Use Distribution Model. This document is the basis of the separately bound Appendix L of the BS/C Study. The FG members provided input on modifications to the initial recommendations. The modifications to the initial recommendations became the final FG member safety risk recommendations.

Meeting notes taken from tape recordings of these meetings are presented in the separately bound Appendix K. The meeting tapes are on file with the BLM in Medford.

II: STUDY METHODS AND PROCEDURES

A: Introduction

This chapter presents a semi-chronological and semi-procedural step by step walk through the Rogue River Boating Safety and Conflicts (BS/C) Study effort. It reviews the various study background steps undertaken, the development of field study procedures and field work execution, the logic behind the BS/C assessments and the development and interaction of the various modeling and assessment components of the BS/C evaluations, and the development of recommendations.

The following discussion is keyed to the BS/C Study procedures developed and executed on the Hellgate Study Reach. Much of the same initial effort was expended on the Gold Hill Study Reach however, due to lack of adequate data, relatively low visitor use, and relatively low magnitudes of apparent BS/C issues, detailed FC Use Distribution modeling and Safety Risk/Conflict modeling were not undertaken.

B: Study Methods and Procedures

1) Project Initiation:

The goals of this BS/C Study included: 1) the determination of the extent to which boating safety and conflict (BS/C) need to be addressed in on-going recreation planning efforts; 2) the identification and evaluation of existing and potential boating safety conditions and/or problems; 3) the identification and assessment of attitudes, perceptions, and tolerances of users for boating safety conditions and boating conflicts; and, 4) the development of BS/C recommendations. This BS/C Study was initially designed to combine a wide range of physical and measurable channel, flow, boat, and boating characteristics into a probability model of safety risks which also was to incorporate user perception of acceptable margins of safety. The cosponsoring agency study scope prescribed that the BS/C assessment include conditions in both a low flow range (900-1300 cfs) and a high flow range (1300-2300 cfs).

An initial list of potential safety risk areas was provided by the cosponsoring agencies; they are listed below. The river mileage noted below are those as measured and used in the BS/C Study from upstream to downstream in the two separate study reaches to the center of the referenced site (nearest 0.1 mi.).

Potential Safety Risk Sites
Hellgate Study Reach

Sites	River Mile (downstream from the 6th St. Br.)
Deadman's Island	1.3
Schroder Park	2.6
Eiseman's Stillwater	5.3
Applegate River confluence	6.6
Whitehorse Riffle	7.5
Finley Bend	9.4
Griffin Park	11.4
Bybee Hole/Brushy Chutes	13.2
Highway Hole	14.5
Weatherby/Two-Bit Riffle	16.8
Johnson Island @ Last Chance Riffle	18.7
Hog Creek Boat Ramp area	18.9

Hellgate Entrance	19.2
Dunn Riffle	20.0
Indian Mary Park	21.2
Ennis Riffle	23.9
Galice Chute Riffle	25.0
Galice Store Riffle	25.5
Rocky Riffle	26.1
Mark's Is./Widow Maker Riffle	29.0
Almeda Park	29.3
Argo Riffle	31.0
Wooldridge Riffle	32.8

The initial BS/C Study scope did not list any specific sites of potential safety risk on the Gold Hill Study Reach. During and following the initial WRC-Environmental site review of this study reach by JB and canoe, 9 areas of potential safety risks were identified. These included the following sites by river mile:

Potential Safety Risk Sites
Gold Hill Study Reach

Sites	River Mile (Downstream from Powerhouse Return)
"First Drop"	0.4
Gold Hill Riffle (aka. Baylor Riffle [upper half], and Lampmans Riffle [lower half])	1.0
Gall's Creek Riffle (aka. Lazy Acres Riffle)	2.0
Sardine Creek Riffle	2.9
Rock Point	3.5
Rock Point Riffle	3.7
Silica Narrows (aka. Silica Hole)	4.2
Two Pines Riffle	4.7
Twin Bridges Riffle	6.5

2) Review of Incident Reports:

All incident reports and related information on file with the BLM, the Oregon State Marine Board (OSMB), and the U.S. Coast Guard (USCG) concerning previous JB accidents in the Study Area were reviewed. The purpose of this review was to determine to what extent existing records of previous JB/MTB incidents and accidents could be used in the BS/C Study to identify BS/C issues, to determine if there were safety risks related to MTB uses, and to identify potential safety risk areas.

These incident reports included a broad range of material from newspaper articles to official accident reports. Newspaper articles included both personal opinions written by private citizens published in editorial sections as well as investigative articles written by reporters. Scoping letters from the public input process regarding updating of the BLM Recreation Area Management Plan (RAMP) were included in the package for review. Scoping letters were written by local managing agencies, commercial outfitters, and private citizens. Complaint cards collected by the Josephine County Sheriff's Office as well as official Marine Casualty Investigation Reports prepared by the USCG, accident reports prepared by local sheriff's offices, and the OSMB boating accident statistics were also reviewed.

The great body of this material was editorial opinion on safety, safety related conflict, and resource conflict issues of pvt-JB and MTB operations. As such, most was not useful in addressing the objectives of this review. That material which did provide "factual" and/or descriptive accounts of JB incidents provided insights into the nature of potential accidents involving JB operations. Several accounts related to the grounding of MTBs on gravel and bedrock portions of the channel. Circumstances revolving these incidents appear to range from the casual contact of shallow channel areas incidental to normal JB operations to more extreme events including high speed contact with the bed during evasive maneuvering to avoid other JBs in other-wise open channel areas. Due to the presence of quiet water with available set-down areas at these accident sites, these latter incidents are presumably related to poor operator skills and judgement. Many of these incidents, particularly those involving contact with bedrock shoals, spines, and isolated knobs, have involved at least superficial injuries to passengers and operators and have resulted in significant damage to JB hulls.

Other incidents appear more related to the interactive nature of channel conditions, JB operations, and BS/C issues with other on-river users. These incidents involved such things as evasive on-plane maneuvers to avoid FC that resulted in contact with the bank of the channel, the near over-running of swimmers from swamped rafts by off-plane MTBs, and the required transit of JBs through congested rapid situations because all available stopping areas were occupied by FC. These incidents and accidents often occurred in channel areas with reduced visibility into rapids and riffles and complex channel sections with reduced MTB/JB operational options. This implies that there probably are channel conditions in the study area in which JBs/MTBs may not be able to fully accommodate other users in an entirely safe manner. From some accounts of these incidents it was not clear to what degree either JB/MTB operator skill and judgement and/or channel configuration and other user distribution (or action) circumstances were critical.

With respect to safety and safety related conflict incidents, often the materials reviewed were vague and not site specific and included contradictory evidence and opinion as to the circumstances and consequences. Although the official incident reports focused on documentable facts and witness interviews that go on official record there were differing opinion and statements of fact in these reports and in other materials. Consequently, the accuracy of the details in the incident reports and descriptive accounts could not be certified by WRC staff reviewers and any conclusions drawn for use in the BS/C Study would be subject to serious questioning. For that reason the various reports on safety and safety related conflict incidents were not directly incorporated into the probabilistic risk modeling.

Despite the inappropriateness of using these materials quantitatively as part of the BS/C Study and risk modeling, the information reviewed indicated that there were perceived and real user conflicts between landowners, floaters, anglers, bank users, and JB operations. It also indicates that there were real concerns for BS/C in the study area.

With respect to BS/C concerns, the review of the material led to the conclusion that there were, or that there was the potential for, serious safety risk circumstances in the study area. The details of the incidents, fault and blame, and the consequences in terms of injury and damage, etc. are not as important to the question of BS/C issues as is the simple occurrences of these incidents. Considering just the officially investigated incidents, only slightly different circumstances (such as the position of craft and/or other users) could have led to drastically changed consequences in terms of injury and loss of life to MTB passengers, other on-river floater, and bank users.

From this review it was concluded that the present MTB operation on this portion of the Rogue River, with the present FC user pattern, poses potential safety risks to users. It could not be definitively concluded, however, whether these incidents were rare exceptions within a generally low risk environment or were examples of accidents that may be typical of the study reaches. It is possible that these accidents were typical of those that will occur in the future within a generally high risk environment in which only randomly controlled circumstances have so far prevented potentially disastrous accidents from occurring.

Appendix A, "Incident Report Evaluation" provides more detailed information on this issue.

3) Review of MTB/JB Operations and BS/C Issues on Other Rivers:

During the field season and the subsequent assessment period of the BS/C Study, river recreation managers and state boating agency staff throughout the western US were interviewed by phone to identify river resources with JB uses and JB/FC conflicts, and to determine the assessment/management approaches that have been used for problem assessment and resolution. In addition, site visits were made and interviews were conducted with operators, users, and managers on a wide range of rivers with JB and other on-river recreational uses.

These interviews and site visits were undertaken as part of the BS/C Study in an effort to: 1) understand the general nature of BS/C issues between JBs and other on-river users; 2) determine if quantitative analytic techniques have been previously developed and applied to the physical characteristics of BS/C problems and to what degree they have been successful in identifying and/or resolving BS/C issues; 3) understand how the JB, FC, and general on-river recreational use characteristics in the Rogue River BS/C study area were similar to or different from other resource areas and how that may relate to BS/C issues in the study area; 4) understand how the physical channel characteristics in the Rogue River study area were similar to or different from other resources and how that may relate to BS/C issues in the study area; and 5) develop a framework within which to quantitatively and objectively assess BS/C issues in the study area.

The river resources on which site visits were conducted in Oregon included the "Lower" Rogue River, Deschutes River, and the Hells Canyon portion of the Snake River. The site visits included MTB trips, JB trips with management personnel, and FC trips to review user patterns and channel characteristics. Interviews with management staff, MTB owners and operators were also conducted. Other site visits in the western US were also conducted on the Salmon River in Idaho above Riggins and on the Colorado River in Utah below Moab.

Site visits to a wide variety of New Zealand rivers with MTB/JB/FC uses were also conducted. The site visits included MTB and FC trips on these resources to review user patterns and channel characteristics as well as extended interviews with resource managers, MTB owner/operators, and private JB operators. These included the Ngaruroro, Whanganui, Rangitikei, Buller, Clutha, Kawarau, Shotover, Dart, Rakaia, and the Waimakariri Rivers and the Lake Aratiatia portion of the Waikato River.

On the river resources visited, MTB operations had two basic characteristics. MTB activities on some rivers were oriented toward "thrill" or "carnival" experiences and usually entailed short duration trips (0.5-1 hrs.) on short sections of non-technical water (Class I), in very small high speed craft with an emphasis on close passages of bank, rock, and vegetation features, and the execution of high speed turns and spins. This type of activity was observed only on New Zealand river resources. The second type of MTB activity was oriented toward "tour" experiences. These activities were of extended duration (1-6 hrs.) in small to large craft through relatively long sections of river (10-50 miles) often containing Class II or Class III- rapids. These trips often included interpretative talks emphasizing natural and human history of the resource. "Tour" type MTB activities were observed on US rivers and on some New Zealand rivers. Often "thrill" elements such as tight high speed turns and spins were included on these trips, however, no observations were made of purposefully executed unnecessarily close passes of navigational hazards to provide additional thrill elements. On the Hellgate and Gold Hill study reaches, MTB operations were "tour" types. On the Hellgate Study Reach some additional high speed turns and spins were used to add some "thrill" elements.

During the review of these other river recreational resources on which MTB/JBs were in use, no example was found where the evaluation of BS/C issues were undertaken using quantitative techniques to separate "real" boating safety problems from "perceptions" of safety problems. No assessment example was identified in which physical parameters of channel/hydraulic conditions, JB operational characteristics, or the characteristics of other on-river use activities were used to evaluate and to specify safety concerns.

With one exception resource managers and state boating agency staff reported that JB BS/C issues were limited to recreational resource value conflicts and perceived safety risks not "real" safety issues. Accidents involving JBs were reported as rare, navigational in nature, and usually related to JB operational mismanagement which could have been avoided with better operator skill and judgement.

The exception was the Shotover River, New Zealand, where MTBs operate on a 2.25 mile reach partially in a narrow gorge of Class I water. In this case should the reach have other on-river activity types or even other JBs operating outside a strict operational pattern, limited visibility induced by steep walls and shallow angle turns, narrow channel, and high MTB speeds would result in the inherent possibility of accidents. Without conducting a quantitative assessment of resource or boating conditions and safety risks, the issue of implied inherent safety risk was resolved by an Act of Parliament (Shotover Empowering Act, 1985) dedicating this reach of the Shotover River to the exclusive use of MTBs and to a single MTB company.

The field review undertaken on the various river resources did result in resolving a key factor that appeared of overriding importance for BS/C issues where JBs are involved. This factor was the "inherent" potential or opportunity for JBs to operate safely between "safe stopping" locations. Safe stopping locations are areas of channel where a JB can be brought to a complete stop such that BS/C encounters with other users can be avoided and the JB craft and/or passengers are not endangered during emergency stops or evasive maneuvers.

Variables that result in this key BS/C factor are derived from the relationship between (i) various channel characteristics inherent to the particular river resource and (ii) the operational characteristics of the JBs in use on the river which together dictate the ability of JBs to avoid BS/C issues with other users based on (iii) the user characteristics of those other activity types. Important channel characteristics include channel curvature (radii of turns), line of sight limitations due to vegetation and/or bank conditions, the spatial distribution of shallow and deep channel areas that dictate JB operational modes, and the combination of channel depth, bed materials, water velocity and effective width that dictate where JBs can be safely stopped. Important JB characteristics include operational speeds, water depth requirements for on-plane, drifting, and on-step operational modes, and the distances required to stop a JB from typical operational speeds. Important characteristics of FC and general on-river users include the type and number of craft in use, FC grouping patterns, float speeds, degree of organized behavior, on-river and bank stopping patterns, routes used through various portions of the river, and the location of swimming and bed and bank activities. These parameters, and possibly others, combine in various ways to control the degree to which JBs can proceed either upstream or downstream from one safe stopping point to the next without the possibility of incurring unavoidable potential unsafe encounters with other river users.

Each of the river resources reviewed varied in important channel/hydraulic characteristics, JB operational characteristics, and in the use characteristics of other on-river users involved in potential BS/C issues. Casual, non-quantitative site evaluations, conducted during the course of the Rogue River BS/C Study, indicated that potentially unsafe conditions exist on nearly all of the river resources visited. These observations were based on the presence of the identified key safety element; channel reaches in which JB operators could not see channel areas ahead of the craft to and including apparent safe stopping locations. In most cases these conditions were very limited in extent. Based on this casual "site inspection" level of review, when considering channel, JB, and other on-river use characteristics, it was the general conclusion of this phase of the BS/C Study that the Hellgate Study Reach had the greatest level of potential safety risk among all resources reviewed. The main factors leading to this tentative conclusion included: 1) the technical nature and the narrow channel conditions of riffles and rapids; 2) the distribution of JB stopping locations; 3) line of sight limitations in rapids; and, 4) the relatively high number of FC and the disorganized nature of FC groups that may be encountered by operating MTBs. If quantitative evaluations of safety risks were applied to these other river resources, such as that developed and used in the Rogue River BS/C Study Area, different conclusions could result.

4) Initial Field Review of Safety/Conflict Issues:

In the first days of project work WRC field staff reviewed both study reaches by MTB, Sheriff's patrol JBs, FC, and ground visits to specific sites. MTB operators, private JB operators, marine deputy/JB operators, and a variety of FC and bed/bank users of the study reaches were informally interviewed throughout the field season. In these initial study reach reviews and during the recurrent field work through July 1992, the nature of the BS/C issues began to resolve.

It was concluded that the BS/C study should not be based exclusively on JB navigational issues for a variety of reasons including: 1) a range of operational characteristics of existing JBs in the study reaches were too wide to model effectively at appropriate accuracy; 2) an unpredictable set of potential characteristics of future JBs; 3) the inherent wisdom of MTB owners taking the prime responsibility for their craft and passengers; and, 4) poor MTB operator skill and judgement factors can override any particular JB operational characteristic and can result in accidents regardless of conditions or circumstances.

BS/C Study issues were conceived as having two components: 1) portions of the study reaches in which there were no MTB navigational/operational limitations which would prevent MTB operators from avoiding any and all safety/conflict incidents with any of the other user activity types; and, 2) portions of the study reaches that had MTB navigational/ operational limitations that made safety/conflict avoidance problematical. The conceptual approach was that any accidents and BS/C incidents and/or issues that may occur in the river areas in which there were no JB operational limitations would be a result of the operational choices, skill, and judgement of the JB operator. Regardless of how open the channel, an accident could be generated by a JB operator if the skill and judgement applied were sufficiently poor. These circumstances are independent of craft use, craft operational and channel characteristics and were outside the bounds of safety risk assessment techniques. Conversely, in portions of the study reaches that have channel characteristics that limit the operational options of the craft in use, accident and BS/C incidents and issues could result when even the best JB operator skill and judgment were applied. In these circumstances craft use, craft operational and channel characteristics would all have an influence on safety risk and were subject to risk assessment estimation techniques. Safety risks that occur in these areas were termed "inadvertent" in this BS/C Study because they could occur with the best on-river visual information, the best JB operational skills, and the best operator judgment.

The portions of the channel that had MTB navigational/operational limitations were defined as those areas that due to MTB operational needs and general craft operational characteristics, MTBs must operate along portions of the channel in which MTB and FC routes were not visible to the operator at a point at which the decision to initiate the run must be made. These circumstances were generally at locations where extended reaches of shallow water were ahead of the MTB, usually at riffles and rapids, and channel curvature prevents visual access throughout the shallow reach to the next location the MTB can safely stop.

The cosponsoring agencies reviewed these early conceptual findings and approved the change in general approach.

5) Development of Basic Safety Risk Assessment Approach:

It was determined that BS/C issues in those portions of the study reaches in which there are no MTB navigational/operational limitations would be dealt with via the observation of the nature of BS/C circumstances and input from users and the FG members. For the portions of the study reaches in which there are MTB limitations, the BS/C issues could be considered with a model that incorporates channel characteristics, boat characteristics, and user patterns within these channel portions. A probability estimate of risk could be developed using the likelihood of coincident occupation of these channel reaches by both MTBs and FC.

The BS/C modeling approach to the MTB operationally limited portions of the study reaches was initially conceived as a four step process: 1) determine the inherent safety risks in the Sites Of Concern (SOCs) based on MTB operational characteristics, channel characteristics, and FC user patterns; 2) determine the relationship between varying FC use levels at the SOCs and safety risks; 3) determine the typical daily FC user pattern at each of the SOCs to estimate the number of FC that could be involved with any particular MTB run; and, 4) combine 2 and 3 above to determine the relative safety risk of any particular MTB trip or combination of MTB trips. It was anticipated that this approach would not provide a "yes/no" answer to the question of safety between motorized and non-motorized activities but rather would allow for the development of estimated levels of relative safety risk between different recreational scenarios. These scenarios could include factors such as different MTB craft operational approaches, different MTB trip itineraries and/or schedules, different levels of FC activity, different physical conditions of the SOCs, different flow levels, and different SOC management practices. The modeling product was seen as a potential planning/assessment tool.

The cosponsoring agencies reviewed and approved this proposed approach to developing estimates of safety risks and conflict late in the 1992 field season.

Fortunately the field work was initially designed to develop a wide base of user information at access points and at potential SOCs. As it turned out this information was appropriate for use in a BS/C probabilistic risk model along the lines of that conceived late in the field season even though most of the field data was collected before the modeling approach was developed.

6) Site-Of-Concern Selection:

All rapid/riffle areas of both study reaches were reviewed and the boundaries of MTB set-down areas were defined. The set-down thresholds were based on the presence of the estimated depth requirement for setting down of 3 ft. over a portion of the channel at least 20 ft. wide. All the rapids and riffles were identified that had unseen channel portions which included MTB/FC routes between the upstream and downstream MTB safe stopping areas. Rapids and riffles that had no site limitations, as defined above, but which had set-down threshold and line of sight geometry that indicated there could be circumstances which would limit the ability of MTBs to accommodate FC were also identified. These were determined to be the portions of the study reaches with MTB navigational/operational limitations and were defined as Sites-of-Concern (SOCs). In addition to the on-river review of channel characteristics, the location of all reported JB accidents were reviewed and those that were associated with FC or bed and bank users were identified. The sites of these incidents were reviewed on-river and those that may have involved JB operational and line of sight limitations were identified as SOCs.

User data and site observations were collected throughout the field season at all sites that had characteristics that could potentially result in "inadvertent" BS/C issues. This was done to assure that at the time that the BS/C modeling was undertaken enough data would be available to evaluate all the possible SOCs. In some cases potential SOCs were identified late in the field season and as a result SOC date bases varied considerably in size.

Location names commonly used on-river were sometimes found to be different from those listed by the cosponsoring agencies and used on some river maps. As appropriate the place names used for the SOCs in the BS/C Study are the geographic references that seemed most commonly used on the river.

Based on JB/MTB operational characteristics and channel configuration parameters the SOCs identified for detailed BS/C risk assessment included:

SOC	River Mile
Hellgate Study Reach	(downstream from the 6th St. Bridge)
Middleton's Riffle	5.9
Applegate	6.6

Whitehorse Riffle	7.5
Brushy Chutes	13.4
Two-Bit Riffle	17.0
Hog Creek Islands (aka. Last Chance Riffle)	18.7
Hellgate Riffle (aka. Hog Riffle)	19.2
Dunn Riffle	20.0
Ennis Riffle	23.9
Upper Galice Chute (aka. Galice Chute)	25.0
Lower Galice Chute (aka. Galice Store Chute)	25.5
Rocky Riffle	26.1
Mark's Island (aka. Widow Maker Riffle)	29.0
Bailey Riffle	30.1
Argo Riffle	31.0
Wooldridge Riffle	32.8

Gold Hill Study Reach;	(Downstream from Powerhouse Return)
"First Drop"	0.4
Gold Hill Riffle (aka. Baylor Riffle and Lampmans Riffle)	1.0
Twin Bridges Riffle	6.5

7) Initial Delineation of Navigational/Operational Limitations of SOCs:

Project timelines dictated that during the 1992 summer field season, important user data had to be collected when the assessment approach to BS/C issues was still under initial development. This meant that all the user data that would ultimately be part of the BS/C assessment would have to be collected before a specific assessment approach was developed. An initial review of MTB operational limitations in the SOCs was undertaken to focus the limited field time available for the collection of user data on the potentially most important aspects. The initial review of operational limitations was used to identify critical Line Of Sights (LOSs) in the SOCs by locating possible MTB operator decision points and key FC location thresholds that could create BS/C concerns. The LOSs were used to determine LOS thresholds along FC float routes that separated seen from unseen FC from critical MTB operator decision points. The LOS thresholds were used to establish timeline segments in the SOCs. The timeline segments were established so that FC and MTB transit rates in critical SOC reaches could be measured.

Each of the SOCs were boated by Sheriff's Office patrol JBs and MTBs several times in each directions. Various aspects of MTB/JB operations were noted for each operational direction including: 1) locations of MTB stops prior to run initiation; 2) set-down areas used and/or available; and 3) routes used. The SOCs were floated by canoe and inflatable kayak, and were visited by shore access to determine general FC route patterns.

Using MTB and FC use characteristics, critical points of origin of MTB LOSs were established. With respect to MTBs, critical LOS were established by first observing MTB use patterns including specific route alignment and the locations used by MTB operators for visual access into SOCs. With respect to FC, critical LOS thresholds were established by identifying key locations where FC users would be lost from sight for extended periods of time in the SOCs or where they could suddenly come into view. From these locations, LOSs were projected backwards to the MTB route alignment to establish the points of LOS origin for MTB operations. The LOS were used to divide the channels through the SOCs into MTB/FC operation segments in which the operational speeds of the various JBs and FC could be used to determine whether or not there were potential BS/C problems. The operational segments were established where the critical LOS crossed routes used in the SOCs by either JBs or FC

Figure 2
Rogue River Boating Safety/Conflicts Study

HELLGATE STUDY REACH

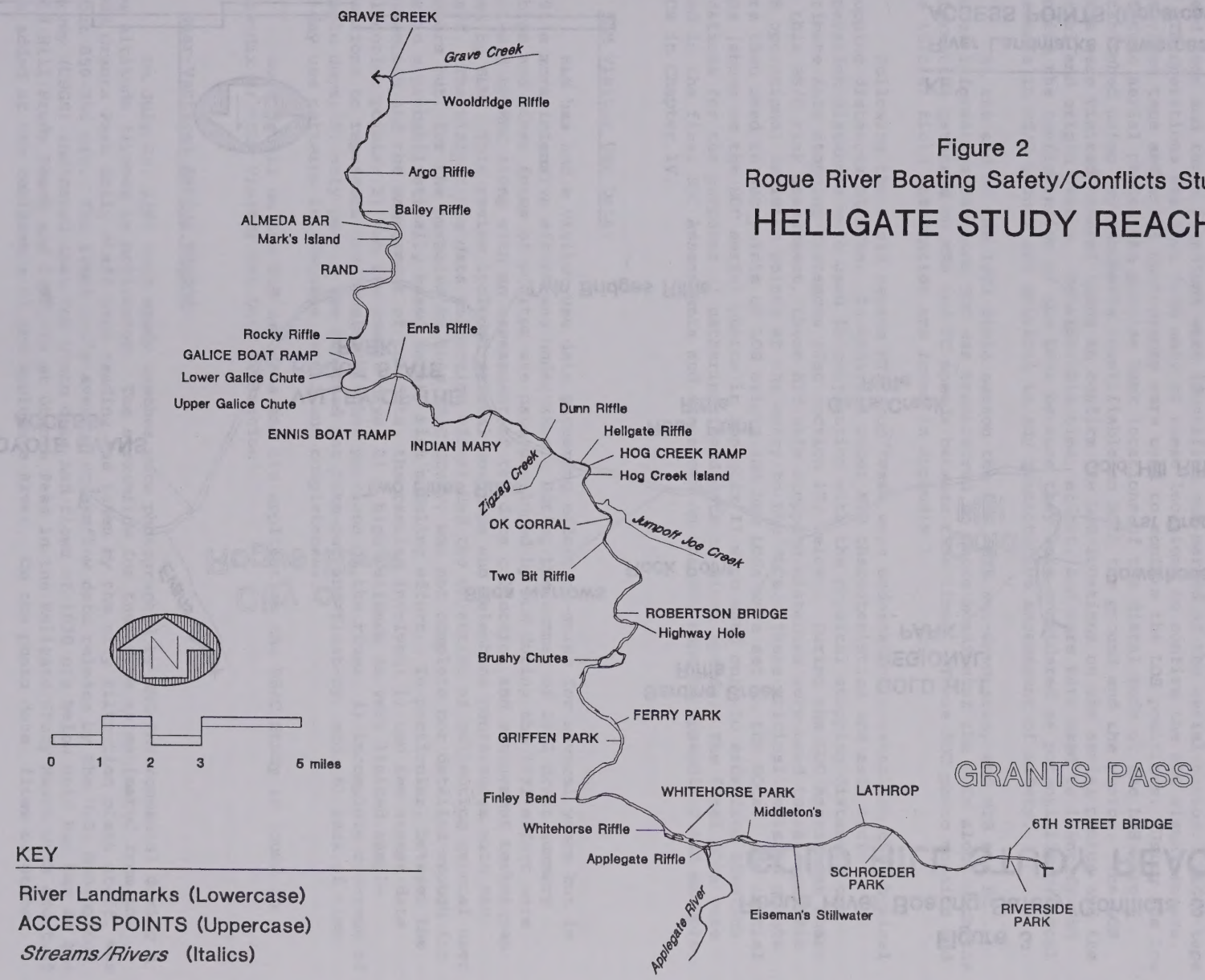
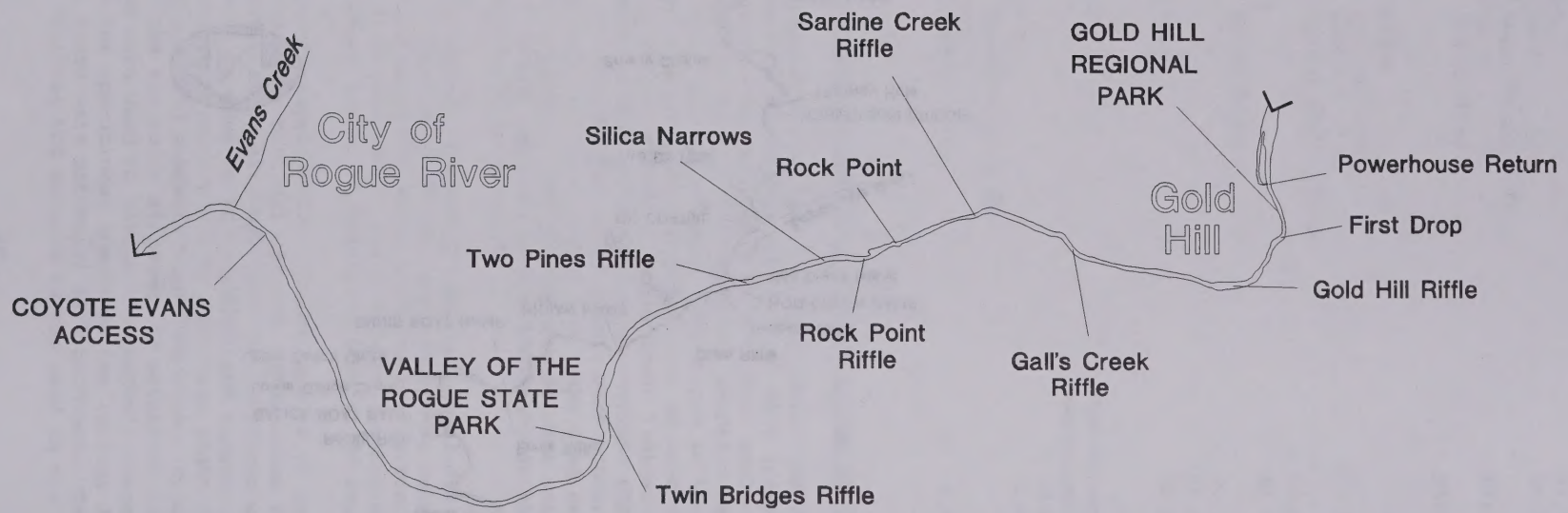
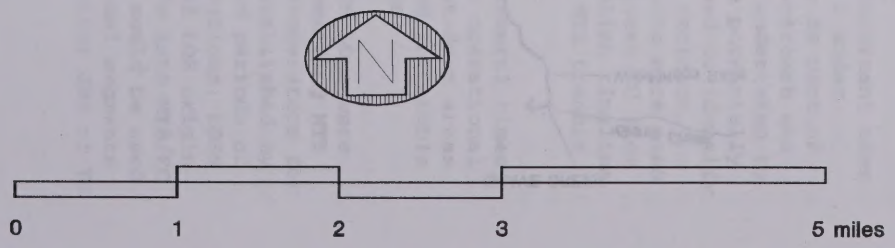


Figure 3
Rogue River Boating Safety/Conflicts Study

GOLD HILL STUDY REACH





KEY

River Landmarks (Lowercase)
ACCESS POINTS (Uppercase)
Streams/Rivers (Italics)

as appropriate. The operational segments were delineated by "timelines" located perpendicularly across the channel. These timelines were initially developed on hand-drawn maps of the SOCs and were used initially for field data collection.

Later, when low altitude aerial photos became available, the critical LOSs were reviewed in detail. For those critical LOSs that resulted from MTB visual access into the SOCs, bank locations were established that provided visual positioning for the BS/C Study field team and those locations were identified and marked of the aerial photos. Video tape of MTB operations was shot from many of these locations to confirm the SOC visual access. The video tape and still photography were used to confirm the LOS positions. Using the low altitude aerial photos the precise bank locations of the distal ends of the LOS were established using key landmarks identifiable on both the ground and the photos. The LOS areas were visited several times to confirm the LOS locations on the aerial photos and the distal and origin points. Considerable time, effort, and care were used to identify and confirm the configuration of the LOSs because they were considered as potentially critical elements in BS/C issues and critical in any quantitative assessment of safety.

At the end of the 1992 field season the LOS, MTB set-down area, and MTB and FC routes information for each SOC was transferred to photo mosaics of the SOCs along with the information gathered on MTB and FC speeds between time lines. These SOC photo mosaics and the initial field information are found in Appendix I.

Following the field season MTB stop tests were undertaken to establish the physical stopping distances of MTBs. In addition other MTB characteristics and safe craft separation distances were used in conjunction with the physical stopping distances to estimate safe stopping distances (See section 17, below). During the SOC Assessment phase of this BS/C risk assessment, these MTB safe stopping distances were used to set specific MTB operational decision points at the entry to the SOCs. These critical decision points were then used to set points of LOS origin and new LOSs were set in the SOCs. The initial LOSs (shown on the SOC aerial photos in Appendix I) were used only to establish timeline locations for the purposes of gathering field data on float speeds. The final LOSs were used in the final SOC Assessments and are shown on the SOC maps in Appendix J and example SOCs in Chapter IV.

8) BLM Visitor Use Data:

BLM has had a visitor use data gathering effort on-going for several years but in 1991 a more intensive effort was undertaken. During the summer of 1992 draft summary tables and other forms of visitor use data developed by BLM during the 1991 effort were reviewed by WRC along with an assessment of the data collection and management techniques used by BLM. This review included several meetings and telephone conferences with BLM staff. The visitor use data collection effort had the objective of collecting general user numbers but, for the purposes of this BS/C Study, was not complete nor detailed enough for use in a probabilistically based safety risk modeling effort. In particular, between the collection and the management of the data, the results involved: 1) too few access data collection points; 2) too few sample days; 3) a high reliance on very limited sample locations to represent use levels at other portions of the river; 4) incomplete coverage of sample days; 5) only put-in use reported not take-out and float-by; and, 6) lack of time-of-day use patterns in adequate detail and completeness.

More detail on the BLM use data and its application the BS/C Study is found in Appendix B; "BLM Visitor Use Data Evaluation".

9) Near-Vertical Aerial Photos:

On July 28, 1992 both study reaches were photographed by WRC-Environmental during a low altitude flyover by helicopter. The streamflow for that date as estimated from the USGS Grants Pass daily staff gage reading, as taken by the city filtration plant staff, was about 850-950 cfs. The final daily average streamflow data release by the U.S. Geological Survey (USGS) indicated that the photo date had flows of 1030 cfs below Gold Ray Dam in the Gold Hill Study Reach and 1000 cfs at Grants Pass in the Hellgate Study Reach with about 45 cfs added at the confluence of the Applegate River. On the photo date, flows of other

tributaries were very low so little accretion was expected to have occurred between the Applegate River and Grave Creek. The hours of the photography work was between 0930 and 1130 hrs. These hours were selected to: 1) take advantage of low sun angles to reduce reflection; and, 2) take advantage of morning hour water clarity in order to maximize the observation of channel bed characteristics (See Figure 23).

These near vertical aerials were used to create photo atlases of the study reaches and for the SOC aerials in Appendix I.

10) Access Point User Data Collection:

FC user pattern information was needed for safety risk probability modeling procedures. This FC data was required as the basis of a predictive FC use model that would provide estimates FC activity levels at the various SOCs at various times of the recreation day. FC user data was collected by WRC-Environmental at a majority of the 16 formal access locations in the Hellgate Study Reach and the 5 formal access locations in the Gold Hill Study Reach. On the Hellgate Study Reach user data was collected from late June through early September 1992 on 60 sample days at 10 access locations. The hours of data collection were staggered so that at most sites a full recreation day use pattern could be developed from a composite of several sample days.

The data collected included the time of take-out, float-by, and put-in to the nearest minute on a craft by craft basis. A "take-out" was recorded if FC were landed (regardless of the duration of the stop) in the vicinity of the access location and a "put-in" was recorded when a FC was launched to the river and the trip started (or a trip was resumed). "Float-bys" were only recorded when a passing FC did not stop at all at the access location. Each craft was recorded separately but noted as part of a group as appropriate. The craft types (driftboat, inflatable kayak, oar raft, rubber ducky, etc.) were recorded and the number of occupants were noted. For purposes of the encounters portion of the safety risk model it was anticipated that FC craft numbers and distribution would be more meaningful than the number of users.

Field and data sheets are on file with the BLM in Medford.

11) SOC User Pattern Data Collection:

From early July to early September 1992 WRC-Environmental field staff collected data on boating use characteristics at the identified SOCs. User information was collected on field forms and on video tape for later evaluation. SOC user data was collected during 85 sample days at 17 potential SOCs on the Hellgate Study Reach and on 4 sample days at 3 potential SOCs on the Gold Hill Study Reach. The number of days on which data was collected varied between SOCs and study reaches depending primarily on the degree of assumed risk and the relative number of FC users. For both JBs and FC, the use characteristics data included the time of arrival at the top of the SOC (and the bottom in the case of upstream operating JBs) to the nearest minute, routes taken through the SOC, transit times in seconds between the established timelines, and any unusual use patterns or mishaps that might relate to the JB/FC safety interrelationships. These last factors included flips, swims, broaches on rocks, etc.

Boat characteristics included craft types (driftboat, inflatable kayak, oar raft, rubber ducky, etc.) were recorded and the number of occupants were noted. Each craft was recorded separately but noted as part of a group as appropriate.

The field data sheets and field video tape are on file with the BLM in Medford.

12) Study Reach Photo-Atlases:

Large scale photo atlases for each study reach were created as field and assessment aids. The near vertical aerials taken for the study were used as the basis for the photo atlases. Separate aerial images were cut and spliced in a manner that minimized side-frame distortion. When aligning the individual photos to create the photo atlas sheets,

digitized USGS 7.5 minute quad topo maps were used to maintain appropriate channel curvature and alignment. The scale of each atlas sheet was estimated independently using two separate approaches. First, in the field random locations were selected for distance measurements between identifiable features on the photos. Second, common locations on the photo-mosaic atlas sheets, on blown-up mid-altitude aerial photos, and on the USGS digitized maps were identified and the scale of each atlas sheet was computed.

These photo-atlases are on file with the BLM in Medford.

13) AutoCAD Mapping:

Digitized 7.5 min quad sheets were obtained from the USGS in AutoCAD format. The stream and road layers from the AutoCAD files were spliced together to cover the entire study reach for use as a base map. Printouts from this file for specific portions of the river were used to assist in scaling the aerial photos and aligning the photo mosaic atlas sheets. Because the intended display scale of the USGS topo map was 1:24,000 (7.5 min. quad) much of the detail of the river and shore line was generalized. The much larger scale aerial photos taken as part of the BS/C Study were used to modify and enhance channel and shoreline details on the AutoCAD file.

The AutoCAD atlases are on file with the BLM in Medford.

14) Initial MTB Operational Limitations Mapping of Study Reaches:

In late September 1992, MTB operational limitations were delineated throughout the Hellgate Study Reach. This field review was conducted when the flow was at about 850 cfs as indicated by the daily staff gage reading at the USGS Grants Pass gage available at the time of the survey. This was about the same flow that was predominant in July and early August 1992. Critical MTB depth parameters were: 1) general depths greater than 3 ft. through a channel area at least 1.5 times the widest MTB (about 20 ft.) which was considered necessary to stop a JB; and 2) depths less than 0.75 ft. which was considered the limit of "no-contact" on-plane navigation. Although these MTB/JB draft thresholds were not field measured nor confirmed they were the general consensus of all the MTB/JB operators interviewed during the BS/C Study.

A graduated depth rod was used to determine the general channel 3 and 0.75 ft. depth boundaries. During this effort the entire Hellgate Study Reach was covered by canoe and/or wading. The MTB operational area boundaries were marked on a field set of the photo atlas sheets. The general channel areas of greater than 3.0 ft. in depth were considered as possible set-down areas; these were areas where a JB can be on-step, transitioning between on-plane and off-plane modes. The edges of these areas were considered set-down thresholds or locations where the JB must be either fully off-plane or on-plane. The general areas with depths greater than 0.75 ft. were assumed to be available for on-plane JB operations. Areas with depths less than 0.75 ft. were assumed to be shoals and non-navigable by JBs in any operational mode.

During the field measuring effort at an apparent flow of about 850 cfs the waterline of the relatively consistent August 1992 streamflow of about 2250 cfs was easily observed by the dried attached algae on the bank rocks and on the shoreline gravel. At the same time that the 850 cfs field measurements were taken, the measured vertical differences in the 850 cfs and 2250 cfs waterlines were used to delineate the 2250 cfs JB operational limitation areas based on the same depth criteria.

The MTB operational limitations were plotted on the photo-atlas for the entire Hellgate Study Reach at both flows.

On the Gold Hill Study Reach the JB operational limitations were developed by a combination of BS/C Study field review of JB operations and depth measurements, on-river review with the Jackson County Marine Deputy, and the review of the aerial photo atlas sheets by Randy Cort, the owner/operator of Jet Boat River Excursions, in the City of Rogue River, Oregon. JB set-down, drift, and on-plane depth operational limitations were delineated for both the low flow and high flow conditions experienced in the 1992 season. These delineations were placed on the Gold Hill Study Reach photo-atlas.

The photo-atlases showing the initial MTB operational limitations on both study reaches for both flows are on file with the BLM at Medford.

15) Correction of MTB Operational Limitations:

The initial JB operational limitation atlas of the Hellgate Study Reach was reviewed by the pvt-JB operator and MTB operator members of the FG and by the Josephine County Marine Deputy. Comments indicated that the initial delineations did not fully conform to the experience of the JB operators. A meeting was held with the pvt-JB and MTB operators to resolve the discrepancies.

As a result of this meeting an additional MTB operational depth category was added. While too shallow to be on-step, or transitioning between on and off-plane modes, 1.5 ft. of water depth allows MTB/JBs, once off-plane, to drift and proceed downstream in a drifting attitude. Depths greater than 1.5 ft. allows JBs to continue downstream at a slower speed. With this additional drifting operational category (1.5-3 ft.) most problems with the initial delineation were resolved.

The initial JB operational limitation atlas for both low and high flow conditions were reviewed site by site at the meeting. It was agreed by the meeting attendees that for JB operational delineation purposes, "Low Flows" were assumed to be 850 cfs from Grants Pass to Zigzag Creek and 1000 cfs from Zigzag Creek to Grave Creek; "High Flows" were assumed to be 2250 cfs throughout the Hellgate Study Reach. Drift and no-drift reaches were added to the atlas based on the experience of the JB operators and the field experience of the WRC field staff. Each of the delineated set-down areas were reviewed; some were adjusted slightly in size or location, some were added, and some were deleted. Those that were usable for full stopping, stopping to drift, and not really usable were noted. The usability of the set-down areas were noted for downstream and upstream operational directions, low and high flow levels, and pvt-JBs and MTBs.

The information developed at this meeting was delineated on the Hellgate Study Reach photo-atlas. It was considered to be the MTB operational limitations for low and high flow conditions and was used in subsequent BS/C assessment steps. This meeting was tape recorded and the tape and photo-atlas of MTB operational limitation developed at this meeting are on file with the BLM in Medford.

For the Gold Hill Study Reach, the initial MTB operational limitations were considered as appropriate for further use in the BS/C Study assessment. The original photo-atlas sheets marked up during the process of identifying the JB operational limitations are on file with the BLM in Medford.

16) FC Use Distribution Model:

The FC Use Distribution Model was developed to estimate the number of FC at various locations at various times of day. This model was an integral part of the predictive portion of the SR/C Model (see section #22, below) and predicts the number of FC that may be encountered by MTBs at each of the SOCs at any particular MTB time of arrival. The FC Use Distribution Model has main three components: 1) typical day Unit Use Curves (UUCs); 2) a multiplier used to adjust the curves to reflect various use levels; and, 3) 15-minute float segments. This model was applied to the Hellgate Study Reach.

UUCs were developed from FC user data collected during 60 sample days at 10 access points and additional user pattern data from 10 SOCs located adjacent to access points. In some instances the curves were modified to more appropriately reflect long term user patterns based on field observations made during the 1992 season. The curves represent the average FC use level during a typical 1992 day for each of the access locations. The UUCs are termed "typical day" because they represent an average of a single weekday and a single weekend day. The FC use is characterized in 15-minute periods from 8:00 am to 9:00 pm. An "Upstream" and "Downstream" UUC was developed for each access point. Together the UUCs reflect a whole-day, total study reach FC user pattern (See Figures 4-6).

The magnitude of UUCs can be modified for alternative FC levels by applying a multiplier. Various multipliers can be applied to result in use levels reflecting weekday use, weekend day use, alternate seasonal or annual use levels, or even for proposed management scenarios. The use at each location was assumed to change proportionally relative to the multiplier applied. Therefore each UUC retains its basic shape and vary only in magnitude.

The final component of the FC Use Distribution model was the development of 15-minute float segments. The entire study reach was divided into segments that represent 15 minutes of float distance for typical FC under typical streamflow conditions. All access points and all points of potential interest were located in specific 15-minute segments. When a point of interest, such as a SOC, is located between access locations the upstream and downstream UUCs bracketing that location were used in conjunction with the 15-minute float segments to translate the estimated FC uses at access points to the intermediate point of interest.

The field data was collected between early July and early September of 1992, so the UUCs represent the temporal and spatial FC user pattern for the main recreation season of 1992. This involved mostly rafting, inflatable kayaking and related activities; not the notably different driftboat/angling use season of September and other winter months. Driftboat angling occurs on very different portions of the Hellgate Study Reach using very different access points and tend to be active earlier in the morning. The activity pattern of driftboat uses is unique and in order to model driftboating use patterns a different set of UUCs would need to be developed for the access points and a different 15-minute float segmentation would be required to predict the location of driftboats during a JB run.

On the Gold Hill Study Reach a functioning FC Use Distribution Model was not developed because of insufficient use pattern data.

More details on the FC Use Distribution Model are presented in Chapter III and in Appendix C; FC Use Distribution Model.

17) MTB Stop Tests and MTB Safe Stopping Distances:

After a season of observing MTB operations in SOCs it was clear that besides the water depth requirements for on-plane, off-plane, and on-step MTB operations, the most important safety related MTB characteristic was stopping distances from on-plane speeds. During interviews, MTB and JB operators (in the study area as well as on other rivers) claimed that JBs could stop in one or two boat lengths but none of those interviewed had ever conducted controlled tests on stopping distances.

In August 1992 the owner/operators of the MTB companies on both the Hellgate and Gold Hill study reaches were contacted to assist in controlled MTB stopping tests. The owner/operator of MTBs on the Hellgate Study Reach refused to cooperate in any tests. The owner/operator of "Jet Boat River Excursions" on the Gold Hill Study Reach was willing to cooperate but had too few revenue trips to develop a sufficient data base in a day of testing and declined to assist. As an alternative the owners/operators of "Jerry's Rogue Jets" and "Rogue River Mail Boat Trips" on the Lower Rogue River, out of Gold Beach, Oregon, were contacted by WRC-Environmental and they agreed to assist in MTB stop tests.

From a boating safety assessment perspective the most important JB stopping aspects are: 1) the distances required to bring a JB from on-plane operational speeds to a even-keel, shallow draft, drifting mode; and, 2) the distances required to bring the JB from on-plane operational speeds to a full stop relative to the bed and bank. Important variables in these distances included among others, MTB size, horsepower, approach speed, load, and finally, stopping maneuvers used. The stopping maneuver used in the tests was a straight-line stop using maximum but safe stopping effort (See Figure 7). This factor was important because stops that threaten the safety of passengers was assumed to be a boating safety issue itself and straight-line stops were important because stopping to avoid multiple FC may prevent the option of passing FC during the stopping maneuver.

In September 1992, MTB stop testing was conducted by WRC-Environmental on the Lower Rogue River as part of a normal day's operation of the two MTB companies. "Medium" sized MTBs (approx. 30 ft. long, 40 passengers) and "Large" sized MTBs (approx. 40 ft. long, 80 passengers) were tested on a 400 foot course on both upstream and downstream operational legs. About 20 MTB stop tests were conducted and the physical distance to stop completely and the physical distance to achieve a drifting attitude were determined for the two sizes of MTBs over a range of approach speeds.

The MTBs on the two Rogue River BS/C study reaches were categorized into "Small", "Medium" and "Large" based on over-all size, total horsepower, and passenger capacity in relation to the characteristics of the MTBs tested on the Lower Rogue River. The distance required to stop and the distance required to achieve a drifting attitude for the MTBs in the study area were estimated based on the stop test results (See Figure 8). In the Hellgate Study Reach, stopping distance and stopping to drift distances for "Medium" sized MTBs with an approach speed of 25 mph were used. In the Gold Hill Study Reach estimated stopping distances and stopping to drift distances were estimated for "Small" sized MTBs based on boat length relationships extrapolated from the "Medium" sized MTB stopping distances. These "physical stopping distances" were later converted into "safe stopping distances" by applying various margins of safety to account for a variety of circumstances (See Figures 9 and 10, Chapter IV for details). The safe stopping distances were used in the SOC Assessments to determine inherent safety risks.

See Appendix D; MTB Stop Test, and Appendix E; Safe Stopping Distances, for more details. The video tape of these tests is on file with the BLM in Medford.

18) Finalization of BS/C Probability Modeling Approaches:

A probabilistic model of BS/C issues that would combine the physical attributes of the channel and the attributes of the different craft that use the study area, the boating user patterns, and the perception of BS/C concerns of the users is a very complex undertaking. The conceptual approach to a safety risk model for the Rogue River Study Area was under constant development through the field season and subsequent extended analysis period. At the time the field data were collected only a skeletal framework for the assessment and modeling had been developed. The BS/C risk model approach was developed into a final form over the two years of analysis and during the Focus Group meetings.

The BS/C probability modeling approach developed was composed of seven steps: 1) the development of basic modeling assumptions; 2) the development of parameters for safety risk acceptability; 3) conducting SOC Assessments using a "fault-tree" risk assessment approach to determine probable MTB operational scenarios and safety risk parameters for each SOC/scenario; 4) developing estimated levels of BS/C for a range of hypothetical FC use levels for each SOC/scenario; 5) using the FC Use Distribution Model to predict the number of FC that may be in each SOC during a specific MTB run; 6) combining the SOC/scenario safety risk parameters and the predicted number of FC to be encountered to estimate the degree of safety risk and conflicts for a particular MTB/SOC run; and 7) developing an estimated accumulated safety risk for an entire MTB trip by routing a trip through the various SOCs of the study reach.

Further attributes were added to extend the BS/C risk model into a planning tool that could assess the implications of safety risk corrective actions. These included: 1) a seasonal index of safety risks for both the low and high flow conditions to form a baseline condition such that alternative management approaches could be assessed for effectiveness; and, 2) modeling safety risks that may result from changed MTB, FC, and SOC conditions.

19) Modeling Assumptions and Margins of Acceptability:

To develop probability-based safety risk and conflict results from the BS/C modeling efforts it was necessary to develop "rules" that prescribe user behavior in various situations and to develop thresholds that separate acceptably safe from unsafe situations. The operational rules, assumptions and parameters for acceptable craft separation were

developed through on-river field observations of user patterns and user response to craft separation for various MTB operational modes, in-put from the Focus Group, and attributes of risk probability modeling for situations such as boating safety on a technical river.

Operational assumptions that were necessary in order to construct and run a predictive risk model included:

- human errors were ignored; best MTB operator skills and judgement were assumed to always be used,
- MTB operators always make operational decisions that were most prudent with respect to safety risks,
- safety risks were associated with only the lead MTB craft in a convoy,
- lead MTB operator operational decisions were based on only the observable circumstances available to the operator,
- FC users were not able to accommodate MTBs in avoiding safety risks,
- MTBs stop in straight lines to accommodate multi-FC users and the possibility that avoidance maneuvering was not available,
- safety risk estimates represent the occurrence of potential accident situations not accidents and,
- safety risk situations that result from MTB operator errors in judgement, poor skill, or imprudence can occur in SOCs as well as in non-SOC areas and were safety risks in addition to the risk estimates generated by the model.

Safe craft separation thresholds that were developed included:

- minimum lateral craft separation of 40 ft. when a MTB passes FC on-plane,
- minimum in-line craft separations of 1 and 1.5 times the MTB hull length when a stopping MTB approaches FC in SOCs for downstream and upstream directions respectively and,
- MTB safe stopping distances accommodate FC separation thresholds, and MTB passenger and MTB craft safety.

Details on operational assumptions and craft separation distances are presented in the Chapter IV.

20) Determination of Low and High Flow Safety Risk Conditions:

It was initially recognized by the cosponsoring agencies that BS/C issues vary with streamflow magnitudes and that at lower flows safety risk and conflict problems may be intensified due to reduced navigational clearances and reduced margins of safety. The variable risk induced by streamflow magnitude was corroborated by both JB and FC operator members of the FG. During WRC's field work it was also noted that changes in channel/hydraulic conditions and general operating room under lower flow appeared to result in both greater risks and reduced margins for safety. With respect to flow ranges and conditions there were two basic questions: 1) what were the inherent safety risks associated with the two flow conditions at each SOC; and, 2) what were the actual streamflows that create low and high flow safety risks conditions at each SOC.

The first question was addressed by conducting the risk assessments of each SOCs using the 1992 user and channel hydraulic conditions observed under two flow conditions. These conditions were the higher flows that occurred from early August to early September, about 2250 cfs, and the lower flows that occurred in July and early August, generally assumed during the field season to be about 850-1000 cfs. All members of the FG, cosponsoring agency staff, and the WRC field team agreed that the channel/hydraulic conditions present at those two flows were appropriate representations of low and high flow conditions as they relate to safety issues. The SOC Assessments were conducted for each SOC/scenario for the channel/hydraulic conditions present without regard to the actual streamflow quantity nor the range of streamflows over which the two conditions may be present.

For SOC Assessment purposes functional definitions for the two flow conditions were developed. Lower flow conditions were represented by reduced effective channel area, and increased navigational hazards that result in increased MTB operational limitations, reduced MTB operational options, and greater potential safety risks. These conditions occur over an unspecified flow range between, at a minimum, a flow just above a self-imposed MTB navigational limit, and at a maximum, a flow just below that at which channel/hydraulic conditions shift to those with reduced potential safety risks (high flow range). This definition was based on the premise that with declining streamflows, adequate safety margins will degrade before MTB navigation limits are reached.

Higher flow conditions were represented by relatively open channel conditions with larger effective channel areas, increased MTB operational options, and decreased potential safety risks. These conditions occur over an unspecified flow range between, at a minimum, a flow just above that at which channel/hydraulic conditions shift to those with greater potential safety risk (low flow range), and at a maximum, the typical upper limit of flows experienced in the main recreation season.

The second question involves the issue of the actual stream discharges that induce low and high flow channel/hydraulic conditions at the various SOCs. This question is pertinent when considering BS/C concerns at a specific streamflow and when comparing several flows. It was recognized that at each SOC, the transition between low and high flow channel/hydraulic conditions was likely to occur over a flow spectrum of perhaps several hundred cfs and that the point of transition could vary between SOCs by several hundred to perhaps nearly a 1000 cfs. In spite of this variable channel/hydraulic condition aspect, WRC used a variety of field observations and streamflow estimates at different locations in the study reaches to develop overall estimated flow thresholds that separate low and high flow channel/hydraulic conditions. The estimated thresholds were about 1800 cfs for the Hellgate Study Reach and about 1500 cfs for the Gold Hill Study Reach.

The SR/C Model (see #22 below) was set-up to estimate the safety risks at all the SOCs under either one of the two channel/hydraulic conditions. If for any reason it is determined that the threshold flow is some other magnitude, such as 1400 cfs or 2000 cfs, the SR/C Model will provide the same safety risk results for the two channel/hydraulic conditions; only the flows to which these two safety risk conditions would apply would be different. The SR/C Model can be modified to assess a mix of low and high flow channel/hydraulic conditions at various SOCs to accommodate the reality that at a specific streamflow some SOCs may have low flow safety risk conditions and others may have high flow safety risk conditions. This feature allows specific streamflow magnitudes to be assessed for safety risks.

21) SOC Assessment:

Each of the identified SOCs were assessed for "inherent" safety risks and for potential conflicts in both MTB operational directions and for both low and high flow conditions (SOC/scenarios). These SOC Assessments were based on the channel/hydraulic characteristics present in the 1992 season, MTB operating limitations identified in each SOC in the study process, vegetation and line of sight conditions in 1992, observed MTB and FC user patterns in the 1992 season, and the BS/C definitions and margins of acceptability identified during the evaluation process.

There are two major steps in the SOC Assessment process. First is the determination of potential safety risks and MTB operational accommodations if only one FC is in the SOC when the MTB arrives at the SOC. This step uses a "fault-tree" risk assessment approach in which the process of running the SOC by a MTB is traced step by step throughout the SOC to identify potential safety risk situations that can and can not be accommodated for by MTB operational adjustments (See Figure 27). The fault-tree assessment starts at the point at which the SOC was first observable by the operator of an approaching MTB, through the point at which the decision to initiate a run must be made, through each of the MTB operational decision points within the SOC, to the point at which all FC can be safely accommodated at the end of the SOC. To accommodate the basic overall BS/C Study assumptions the fault-tree assessments assumed that: 1) the MTB operators use the best skill and judgement and make

the best effort to both avoid FC encounters in SOCs, and, if encounters occur, to operate MTBs so as to reduce potential risk to a minimum; 2) FC operators do not accommodate MTBs but float through the SOCs using patterns typically observed; and, 3) considering the two above assumptions, any inadvertent MTB/FC co-habitation of portions of the SOC, at less than prescribed craft separation thresholds, was considered a potential safety risk situation and was termed a Mutual Occupation (MO) occurrence.

The fault-tree assessments determine three important BS/C parameters: 1) the probability that if a single FC is in the SOC when a MTB arrives that it will not be seen by the MTB operator and the MTB run will be initiated; 2) this determines if the MTB runs straight into the SOC or sets-down to wait; and, 3) if a single FC is unseen in the SOC and MTB runs into the SOC, the probability that it will be overtaken by the MTB before it drifts to a safe location. The first parameter, 1) above, was referred to as the Probability of Not being Seen (PNS) which drives the second parameter 2) which was the Probability of a run Initiation (PI). The third parameter, 3) above, is the Probability of a Safety Risk (PSR). The PNS and the PSR can be multiplied together to determine the likelihood that an approaching MTB will not see a FC in the SOC but will encounter one in a potentially hazardous situation, the Probability of Mutual Occupation (PMO). These are probabilities based on a single FC occupying the SOC (See Table 2).

The fault-tree risk assessments for example SOC/scenarios are presented in Chapter IV and each SOC/scenario in Appendix J on detailed SOC maps. These maps were created by digitizing the appropriate channel areas from the aerial photo atlases. Each of these maps displays MTB operational limitations such as set-down areas and thresholds, the lines of sight and visual shadow zones, and the MTB and FC user patterns. Also presented on these maps are the computations of PNS and PSR and a narrative of the fault-tree assessment.

The second major component of the SOC Assessment was determining the changing safety risk and conflict conditions at varying levels of FC use for each SOC/scenario. This was accomplished by hypothetically placing from 0 to 50 FC in the 15-minute float segment of each of the SOCs and then estimating the number of FC that would be in the SOC when a MTB arrives. Since this assessment now involved variable FC use levels, this step results in the Probability that the Rapid is Occupied (PRO). Using the same fault-tree assessment procedure as above, the probabilities that all FC in the SOC would be unseen was calculated, the likelihood of a MTB run or stop was calculated, and if a MTB run was undertaken, the probability of a safety risk situation was calculated. This assessment led to estimates of both safety risks and conflicts for each SOC/scenario.

Safety risks were defined as incidents in which inadvertent mutual MTB/FC occupations in SOCs occur. To establish a relationship between FC use levels and potential inadvertent mutual occupation at each of the increments of FC use level for each SOC/scenario the PNS and PSR from the fault-tree assessment were multiplied together with the PRO to result in the Probability of inadvertent Mutual Occupation; PMO. For each SOC/scenario the relationship between FC use levels and safety risks (PMOs) was estimated (Se Figure 29).

Conflicts were defined as those MTB/FC encounters that may be directly related to, or may lead to, safety risks:"safety risk-related conflicts". Conflicts as used here were not related to resource values, recreational quality, or other non-safety issues. For the purposes of this BS/C risk probability model, conflicts were defined to be the degree to which users in conflicting activity types must accommodate each other at SOCs to avoid safety risks. It was assumed that as the frequency and duration of accommodation increases, the likelihood increases that the conflict can transition to safety risks. These induced safety risks could include reducing margins of safety in use patterns, not accommodating the other users at that particular SOC, and/or the accumulation of enforced accommodation through the recreation day that leads to a non-accommodating and confrontational posture at other SOCs. Because of the complexity of conflict issues, MTB wait incidents and wait duration at the SOCs were used as a surrogate for all the possible conflict types that any and all the user activity types may incur.

The assessment of the relationship between varying FC use levels and conflicts for each SOC/scenario follows from the safety risk assessment. The probability that FC were in the SOC and were observed when the MTB arrives at the SOC determines the probability that the MTB will stop before entering the SOC. As FC use increases the probability and

frequency of MTB stops to accommodate FC increases. Once stopped, the opportunity for the MTB to re-initiate the run depends on the presence of a gap between FC large enough for the MTB to proceed through to the end of the SOC without incurring an Overt MO.

Using assumptions as to the spatial distribution of FC at SOCs, the probabilities and average duration of MTB waits can be estimated over a range of potential FC users. This provides for a graphic representation of how often and how long waits may be for each SOC/scenario over a range of possible FC use levels (See Figure 30). In addition this assessment can identify FC use levels that essentially saturate each SOC/scenario. In this BS/C Study the threshold for saturation was defined as a situation in which there is a 100% chance that a wait longer than 15 minutes will occur. Other saturation standards could be developed and used to determine acceptable capacities. This analytic step can be used as part of a carrying capacity assessment based on the physical capacity of river resource to accommodate various users.

Details of the SOC Assessment process, operational assumptions, and the results of the SOC Assessments for the two study reaches are presented in Chapter IV and Appendix J.

22) Safety Risk/Conflict Model:

The Safety Risk/Conflicts (SR/C) Model is operationally based and was designed to combine times of MTB arrival at SOCs, the predicted FC use levels at each SOC from the FC Use Distribution Model, and the "inherent" SOC safety risk elements from the SOC Assessments. The SR/C Model is used to estimate the potential number of MOs associated with any number of MTB use conditions. The model can be used to determine an existing level of safety risk exposure as well as for a range of existing or potential management or operational scenarios. These applications can result in comparative conclusions on the relative safety risk for a set of assumed user patterns and/or site conditions and can be used to estimate the safety risk and conflict implications of modified management actions.

Regardless of the specific application, the SR/C Model uses four steps to estimate safety risks: 1) the PNS and PSR for each SOC/scenario are identified from the SOC Assessments; 2) MTB trips are routed along an itinerary schedule and the times and directions of MTB arrival at the various SOCs are identified; 3) the FC Use Distribution Model is used to estimate the number of FC that are expected in the 15-minute float segment of each SOC at the time of MTB arrival; and, 4) from the expected number of FC in the 15-minute float segment, the SOC Assessment is used to estimate the PMO during each SOC run. From this basic model approach several out-put products can be developed.

One product of the SR/C Model is the estimated probability that one or more MO incidents will occur on a specific MTB trip itinerary schedule (See Figure 32). The number of MOs estimated by the model is based upon the PMOs for each SOC run throughout the itinerary. Since each different MTB trip itinerary schedule runs through each SOC at different times of the day, different numbers of FC are likely to be encountered and different PMOs should result. In addition the various MTB itineraries take the MTB trips through different sets of SOCs. When considering the SOC run time of day variability and the varying SOCs run on each MTB trip itinerary schedule, each should accumulate a different probability of incurring at least one MO. By estimating MOs based on individual MTB trip itinerary schedules these itinerary schedules can be compared for relative safety risk. In addition, when the accumulation of PMOs are plotted along the particular MTB trip itinerary schedule the safest and riskiest portions of the study reach can be visually identified.

Another product is an estimate of safety risks based on a whole season of MTB activities. This whole season application calculates a total MO number for all the MTB trips conducted over a specific portion of the year. The total estimated seasonal MOs is a seasonal safety risk exposure index that represents existing conditions and can be used as a baseline safety risk condition. This approach is useful when the model is used to determine the potential significance of any number of management actions designed to reduce safety risks or to determine the potential implications to safety risks due to changed resource conditions or management actions aimed at other resource attributes.

This model application is based on a hypothetical 101 day long Main Recreation Season (MRS) that includes 68 weekdays, 30 weekend days, and 3 holidays occurring on weekdays. This is the average number of days and day-types in the Memorial Day weekend to Labor Day weekend period, inclusively. Although the MTBs are presently in operation from May 1 to September 31 each year, the more limited MRS was adopted as a standard modeling season because MTB time of day scheduling, MTB trip demand, and FC user levels and patterns are relatively constant over this period. Based on the present MTB trip schedule, in an average MRS there would be 531 and 404 MTB trips scheduled on the Hellgate and the Gold Hill study reaches respectively. The MRS of 1992 included 107 days. In that MRS there were 566 and 428 scheduled MTB trips on the two study reaches, not including "special" trips on the Hellgate Study Reach outside the published schedule. Many of the scheduled MTB trips on the Gold Hill Study Reach were not run due to low demand.

The MTB trip itinerary schedule is used to identify the time of day each SOC is run in each operational direction. The FC Use Distribution Model is used to estimate the PMO for each SOC run for both a weekday and a weekend-day FC use level. The number of time-of-day SOC runs are then tabulated by the number of day-types (weekday, weekend-day, holiday) and a total MRS MO is estimated by tabulating the appropriate number of time of day SOC run PMOs by day-types (See Table 5). This provides a whole season baseline safety risk (MO) estimate. Assuming all recreation days are in either the high or low flow range, a baseline for the low and high flow conditions can be developed. The safety risk implications of any changed element of the recreational environment can then be assessed against the baseline safety risk conditions.

Because sufficient user pattern data was available, the SR/C Model was used on the Hellgate Study Reach to estimate safety risk exposure. The baseline for the two flow conditions for the average MRS were used for the implication evaluation of BS/C recommendations. The baseline MRS MOs for the Hellgate Study Reach are presented in Table 7 of Chapter VII and are used in Chapter VII for some general conclusions on implications of alternative management scenarios.

23) Initial BS/C Recommendation Elements:

The Focus Group (FG) was involved in six meetings, the first four of which involved the consideration of resource values and resource conflicts between user activity types in the Hellgate Study Reach, the review of user perceptions of safety risks and safety risk-related conflicts, and the consideration of safety risk parameters and thresholds used to identify potential risk situations. During the fifth FG meeting members of the FG provided 26 separate initial recommendations that were designed to address identified BS/C issues and to reduce BS/C levels on the Hellgate Study Reach.

The ground rules for the FG included a non-consensus clause which provided that any recommendations proposed by any member of the FG was included regardless of general agreement or concurrence. The FG recommendations were from individual FG members who were proposing solutions from their own experiences and perspectives; they were not representing the interests or concerns of all other users of the same activity type. Therefore the recommendations were from the individual members of the FG based on individual experiences and on the information and discussion in the previous FG meetings. The recommendations were not based on majority vote nor on consensus and were not considered as recommendations from the FG as a body.

WRC also prepared 19 initial recommendations designed to reduce the levels of BS/C on the Hellgate Study Reach. These recommendations were based on field observations and input from the Focus Group.

These initial BS/C recommendations were considered as "recommendation elements" because they were a laundry list of suggestions that could either increase or decrease safety risks and/or conflict problems, could be internally inconsistent, and could be incompatible and/or mutually exclusive. Taken together they were not designed to constitute a discrete and coordinated set of recommendations designed to either achieve specific BS/C objectives or to produce a maximum reduction in BS/C within the context of specified management constraints.

The initial recommendations are listed in Appendix L; "Draft Safety Recommendation Elements - Safety Risk and Conflict Implications".

24) Assessment of Initial BS/C Recommendation Elements:

The initial recommendation elements were evaluated by WRC for their implications to safety risks and conflicts. Some of the recommendation elements were related to the management of the physical attributes of SOCs while others were related to management of MTBs, FC, or MTB trip itinerary schedules. These recommendation elements were suitable for evaluation using the BS/C risk probability modeling approach developed in this BS/C Study. Other recommendation elements were not subject to evaluation using the model. These were evaluated using the experience and 1992 field season observations by the WRC field team.

For those recommendation elements subject to risk probability modeling, the SOC Assessments and the FC Use Distribution Model were used in the SR/C Model to evaluate the BS/C implications. 1992 FC use levels, 1992 SOC physical characteristics and observed MTB/FC user patterns were used in the modeling. The MRS safety risk baselines for high and low flow channel/hydraulic conditions were used as the basis for evaluating the significance of any changes in safety risk results.

Some recommendation elements could result in changes in the PSRs of the SOCs. These included removing vegetation to improve lines of sight, added traffic spotters to eliminate visual shadow areas, changed MTB speeds, and added MTB wait times. To evaluate these recommendations, each of the affected SOCs were reevaluated through the SOC Assessment procedures, as above, and modified PSRs were developed. The effect on MRS safety risks were evaluated by using the new PSRs and running the full MRS MTB itinerary schedule. The implications of these recommendation elements were evaluated by using the new SOC PSRs to determine resulting MRS MOs. The net change in estimated MRS MOs between baseline conditions and those for the modified condition represented the anticipated effectiveness of the recommendation element in reducing safety risk exposure. Therefore effectiveness was measured not by the change in the SOC safety risk parameters such as the PSR, nor by the change in safety risk exposure for a particular MTB SOC run or MTB trip but rather by the change in safety risk exposure over the entire MRS.

Another set of initial recommendation elements involved FC management including, limiting FC use levels, changing access locations, and the management of FC launching at specific locations. These recommendation elements were evaluated by making the appropriate changes to the UUCs in the FC Use Distribution Model to change the expected number of FC to be encountered during each MTB run through each SOC. The effect of these recommendation elements on MRS safety risk exposure were evaluated by using the new PSRs and running the full MRS MTB itinerary schedule.

The last set of recommendation elements that could be evaluated by the BS/C risk probability modeling approach were those that involved MTB management including modified trip itineraries, modified trip schedules, closure days, low flow range closures, and Whitewater Section closures. These recommendation elements were evaluated by developing new MTB trip itinerary schedules and modifying the time-of-day SOC runs as appropriate, using the FC Use Distribution Model to estimate the number of FC that could be encountered, and developing new PMOs for each MTB/SOC run. The effect of these recommendation elements on MRS safety risk exposure were also evaluated by using the new PSRs and running the full MRS MTB itinerary schedule.

The initial recommendation elements had a wide range of potential effects on overall MRS safety risks. The modeling analyses resulted in MRS MOs ranging from 0% of baseline conditions (eliminating all safety risk exposure) to 132% of baseline (increasing safety risk exposure by 32%).

Detailed discussions of the potential implications of all of the initial BS/C recommendation elements are presented in Appendix L: "Draft Safety Recommendation Elements - Safety Risk and Conflict Implications".

25) Final BS/C Recommendation Elements:

The results of the implications of the initial Hellgate Study Reach recommendation elements were reviewed by the FG at the sixth meeting and some modifications to the recommendation elements were made. The initial recommendation elements as modified by the FG members became the final set of 24 FG recommendation elements for reducing BS/C concerns. As with the initial recommendations, the final list of recommendation elements was a menu of possible actions from the members of the FG representing their own views and not a consensus list from the FG as a body.

WRC also developed a final set of 25 recommendation elements for the Hellgate Study Reach from a review of the implications of the initial recommendation elements. Final recommendation elements for the Gold Hill Study Reach were developed by WRC using the final recommendation elements for the Hellgate Study Reach as a basis and selecting those that were applicable to the Gold Hill Study Reach based on the BS/C setting and the recreation management situation.

As with the initial list of recommendations, the final recommendations could be used in combinations that may create redundancies and/or contradictions, increase safety risks, or trade decreased safety risk for increased resource conflicts, etc. For the Hellgate Study Reach, the final recommendation elements were used by WRC to develop sets of recommendations that together could be used for specific safety risk management objective scenarios (See section #28).

The final recommendation elements are presented in Chapter VII.

26) Final SOC Assessment and SR/C Model Procedures:

The entire BS/C risk probability approach was reevaluated following the initial development of the SOC Assessments, the development of the SR/C Model, and running the SR/C Model to evaluate the BS/C implications of the initial recommendation elements. The SOC Assessment procedures were reviewed and improved to accommodate oversights and analytic shortcomings. All of the SOC Assessments for all the SOC/scenarios were then repeated to assure consistency and accuracy. Likewise the SR/C Model procedures were reviewed and improved to more accurately reflect the nature of BS/C issues in the study area.

During the SOC Assessment reevaluation several small modifications were made that resulted in different PNSs and PSRs for some SOCs. This meant that the SOC safety risk parameters used to evaluate the initial recommendation elements were slightly different than those that would result from applying the final SOC Assessment and SR/C Model procedures. These differences were very small and should lead to no significant changes in the implications of the initial recommendation elements. Comparisons of initial and final SOC safety risk parameters are presented on Table 6 in Chapter VII.

The development of the final SR/C Model procedures resulted in more significant changes in estimated safety risk exposure. This was primarily due to an inaccurate method of routing upstream MTBs through SOCs in the initial SR/C Model. The final SOC Assessment and SR/C Model procedures resulted in a 20% increase in MRS safety risks under low flow conditions and an 8% increase under high flow conditions. Comparisons of initial and final SR/C Model results are presented on Table 7 in Chapter VII.

27) Hazard Severity Rating:

The SOC Assessments were designed to determine the probability that potential hazard situations would occur. These PMOs relate to the probability of inadvertent MTB/FC MOs in SOCs. When the PMOs from the SOC Assessments were combined with FC user levels and MTB trip itinerary schedules the SR/C Model is used to calculate the accumulated number of MOs that may occur over a specific time period and under specific circumstances. In addition these MOs are only a tabulation of potential MTB/FC encounters in hazardous locations, not estimates of accidents. All potential MO situations were given the same significance weighting regardless of the location and circumstances.

Clearly the nature of these circumstances vary, some MOs were more likely to lead to accidents, and accidents, should they occur, would vary in the severity of the outcome with respect to damage, injury, and loss of life.

A Hazard Severity Rating (HSR) was developed to provide a measure for the relative significance of each of the identified possible MO situations for each SOC/scenario. This rating was based on the likelihood that specific MO situations would occur, the probability that an accident would result if the MO element occurs, and the relative severity of the possible outcomes of the accidents. The relative severity was based on MTB operational modes and likely speeds at the time of the accident, the maneuvering room available to avoid the accident, the potential for multi-FC encounters that would reduce MTB avoidance potential, reaction time available to the MTB operator, and the likely craft separation distances at the time of the incidence.

The HSRs were assigned to MO situations based on the professional judgement of the WRC-Environmental field staff using the results of the SOC Assessments, on-river observations of user patterns, and the observations of potential safety risk situations. The HSRs were not used in any quantitative way with the SR/C Model to weigh the MOs for significance. They were developed for the use of resource managers and river users in the prioritizing of safety risk concerns and possible management actions.

Because the HRS process was not used as a formal part of the BS/C risk modeling approach in this study, it is not presented in the main report. The HSR process, functional definitions, and the HSRs for each MO situation are presented in Appendix H: Hazard Severity Rating.

28) Final Boating Safety and Conflict Recommendations:

As a final step in the Rogue River Boating Safety and Conflict Study, WRC organized the final BS/C recommendation elements for the Hellgate Study Reach into a range of recreation management scenarios. Six recreation management scenarios were developed which combined sets of complimentary recommendation elements. Each scenario had the objective of achieving the maximum possible reduction in BS/C issues within the confines of different management objectives and different assumed levels of acceptable impact to recreational users. Each management scenario was defined, the appropriate recommendation elements listed and a brief review of the implications of the scenario were developed. The recommendation elements used in these management scenarios were selected by WRC-Environmental from the final list of recommendation elements provided by the FG members and WRC. The six management scenarios for the Hellgate Study Reach are presented in Chapter VII. A summary of the recommendation elements in each management scenario is presented in Table 8.

Safety risk reduction recommendations for the Gold Hill Study Reach were developed by WRC based on on-river observation, preliminary fault-tree assessments, and the recommendations developed for the Hellgate Study Reach. However, management scenarios were not developed because of the lack of goal oriented general recreation management entities in that area. While the Oregon State Marine Board and the Jackson County Sheriff's Office have interests in boating safety on that reach, there is no agency presently concerned about the recreation value trade-offs associated with changed recreation patterns that could result from safety risk management nor agencies with the authority to approach recreation management in a coordinated fashion.

III: FC USE DISTRIBUTION MODEL

A: Introduction

The basis of the BS/C modeling assessment is the probability that safety risk and/or conflict situations will develop in the SOCs of the study area as a result of MTB and FC activity. The SR/C Model (Chapter V) addresses these probabilities by combining the safety risk aspects of specific SOC/scenarios (Chapter IV) with the estimated number of FC that may be encountered by MTBs in the SOCs. The FC Use Distribution Model is the basis for estimating the number of FC that can be expected to be encountered at various SOCs at various times of the day by arriving MTBs. Estimates of expected FC numbers at any location in the study reach is based on the general daily FC use levels and the distribution of FC use throughout the typical recreation day in the study reach. The FC Use Distribution Model was developed to predict number of FC that may be encountered by MTBs at each of the SOCs under a variety of use levels.

Time constraints limited the number of sample days available for the collection of user pattern information. Because of the high degree of BS/C concerns in the Hellgate Study Reach data collection efforts were concentrated on that portion of the study area with the objective if collecting enough information to develop an adequate FC use model. Although this FC user model only applies to the Hellgate Study Reach from Grants Pass to Grave Creek, the FC Use Distribution Model construct can be applied to the Gold Hill Study Reach should enough reliable user data be collected in the future. The limited user data collection effort on the Gold Hill Study Reach prevented BS/C issues from being addresses through a probabilistic BS/C modeling assessment approach.

The FC Use Distribution Model has three main components: 1) typical day "Unit Use Curves" (UUCs) reflecting the temporal daily use patterns at various access locations; 2) a multiplier used to adjust the magnitudes of UUCs to reflect various use levels; and, 3) 15-minute float segmentation that allows for FC use estimates at access locations to be translated to various SOC locations.

As a result of the basic construct, the FC Use Distribution Model can be modified to accommodate a variety of recreation conditions and recreation management scenarios. The amplitude of the UUCs can be adjusted to reflect the temporal and spatial distribution of FC at different seasonal or monthly use levels and weekday/weekend day multipliers can be adjusted to reflect differing relative demand or user dislocation between these day-types. The shape of specific UUCs can be adjusted to reflect facility carrying capacity limits and changes in access capacity. New or abandoned access points can also be accommodated by adding and/or deleting access point UUCs. Any time individual UUCs are modified for whatever reason or new access UUCs are developed, all the UUCs of the study reach that could be effected also need to be adjusted and made interdependently consistent. In the adjustment process, adjacent access point UUCs must have matched FC magnitudes and the curve shape must reflect expected FC float times and user patterns between the access points.

The field data used to develop the FC Use Distribution Model were collected between early July and early September of 1992 on 60 sample days at 23 locations. The UUCs represent the temporal and spatial FC user pattern for the main recreation season of 1992. This involves mostly rafting, inflatable kayaking and related activities not the notably different driftboat/angling use season of September. With respect to typical FC uses, driftboat angling is concentrated on very different portions of the Hellgate Study Reach using different accesses and tends to be more active early in the recreation day. They also spend considerable time (0.5-2 hrs. or more) angling in specific locations rather than simply floating downstream. The activity pattern of driftboat uses is unique and in order to model driftboating user patterns a different set of UUCs would need to be developed for the access points and a different 15-min float segmentation would be required to predict the location of driftboats during a MTB trip.

Driftboat angling activities were unusually suppressed during the 1992 BS/C Study field season. Particularly low flows in that year and water resource and fishery resource management decisions resulted in delays in increased fall season dam releases. These releases are used to induce upstream migration of fall run Chinook from the mouth and the delays resulted in very low angling activity in the study area during the 1992 field season. Driftboat activities were too low to use field data to characterize typical user patterns. Only a few days were spent specifically observing driftboat angling. A FC Use Distribution model was not developed for the fall season driftboat angling activities. A meeting was held, however, with six driftboat anglers to determine the typically used access points, time of day, and on-river spatial user patterns for these users. The meeting was tape recorded and the tape is on file with BLM at Medford.

The a more complete discussion on the FC Use Distribution Model is presented in Appendix C.

B: Unit Use Curves

Unit Use Curves were developed in the Hellgate Study Reach for the upstream and downstream sides of 10 access points and for one side of 2 access points; a total of 22 UUCs. These UUCs reflect the "typical day" FC temporal use pattern at these locations by relative magnitudes of activity in regular time intervals. The total FC activity at a site for a typical day is reflected by the volume under the curves. The total FC use activity at each UUC location is adjusted such that adjacent access UUCs (such as the downstream UUC at Robertson Bridge and the upstream UUC at Hog Creek Ramp) have matched total curve volumes. While the total FC use magnitude of adjacent UUCs are the same, the shapes and temporal distribution of use through the time intervals are different reflecting the FC use pattern and float times between the sites. The UUCs were developed from the FC user data collected during the field season, some FC use data collected at SOCs, and modifications based on field observations during the 1992 season. The SR/C Model is based on the number of FC that may be encountered in SOCs. Therefore the UUCs display the daily FC use pattern in numbers of floatcraft, not floatcraft user numbers.

The UUCs are constructed based on FC use activities on a time interval duration of 15-minutes. A 15-minute duration interval was chosen because: 1) the data reasonably portrayed the likelihood of FC use at a SOC at a particular time of day; 2) it can accommodate the expected variable range of MTB deviation in scheduled arrival from incidental causes; 3) it is short enough to maintain the temporal variability of the general daily FC use pattern; and 4) it is long enough to moderate "spikes" or "noise" in the use pattern that result from, a) limited field data, and b) the natural random clumping pattern of FC users and the incidental nature of arriving in one time interval verses the next interval.

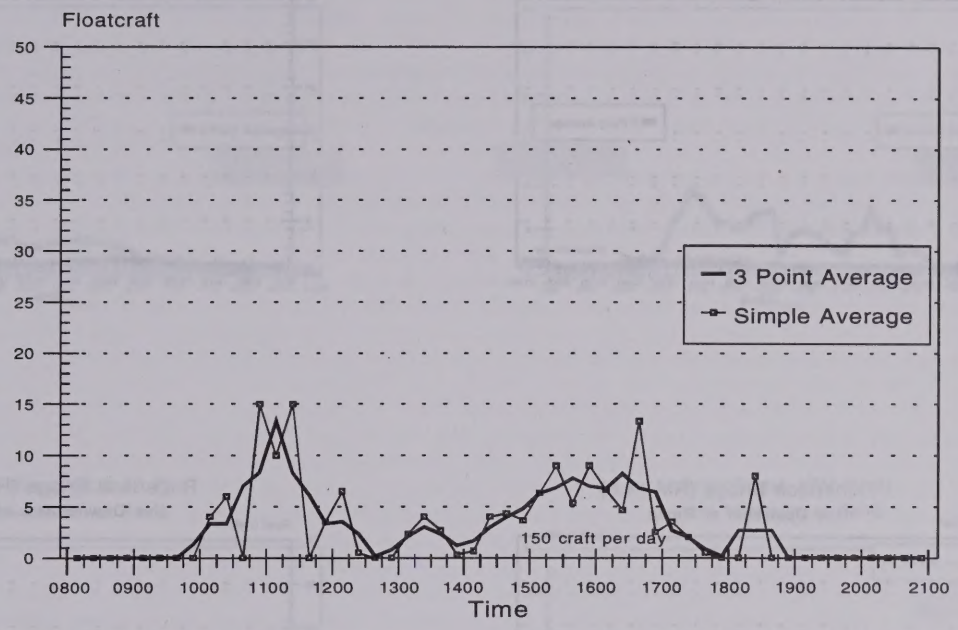
The individual UUCs are constructed from minute-by-minute field recording of FC activity at the various access sites. The recorded FC put-in, take-out, and float-by activity data was first collapsed into 5-minute intervals and then into 15-minute intervals. The upstream UUCs were constructed by adding the average float-by and take-out data and the downstream UUCs were constructed by adding the average float-by and put-in data for each 15-minute interval. The "Simple Average" curve in Figure 4A shows that even with a 15-minute duration interval a spiky FC user pattern is evident.

The final UUCs are constructed from a 3-point running average of FC use activity in 15-minute intervals throughout the recreation day. The 3-point running average was employed because of an inherent degree of random noise in FC use distribution and it provides more appropriate reflection of long-term average FC use distribution conditions. The 3-point averaging approach tends to smooth out the curve and reduces the magnitude of both "high" and "low" extremes. The 3-point average curve on Figure 4A peaks at about 13 FC in one interval while the simple average curve peaks in 3 intervals at 13, 15, and 15 FC. In the main use period of 0930 to 1900, the 3-point average curve also has fewer intervals with no FC; 4 v. 11.

Figure 4B shows the same downstream UUC for the Argo Ramp but has been supplemented with 5-minute and 15-minute peak data to further exemplify the clumped and spiky nature of the FC use pattern. The 3-point average curve that is used in the FC Use Distribution

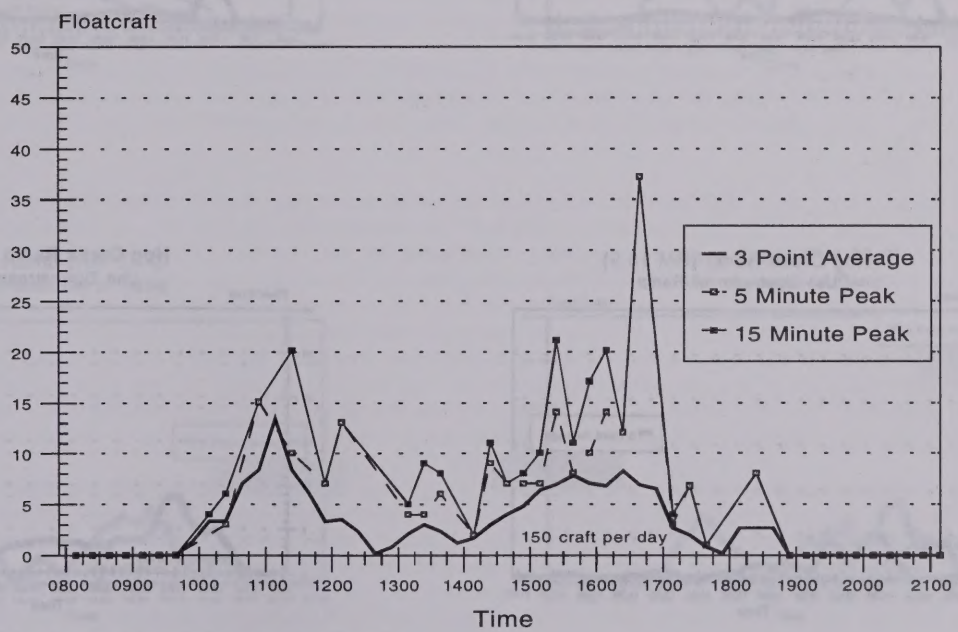
Figure 4
Sample Unit Use Curves
Use downstream of Argo Ramp

A: Simple and 3 Point Average Curves



Average daily float craft for a weekday and a weekend day

B: 3 Point Average and Envelope Curves

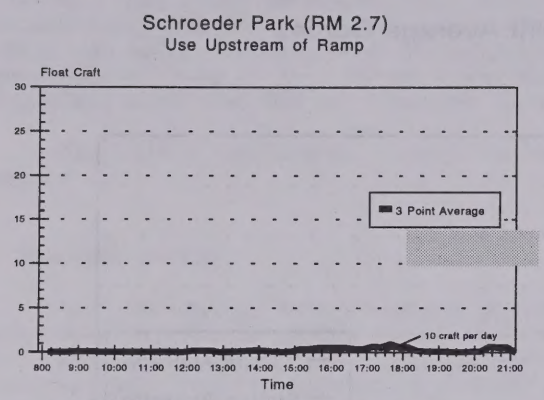


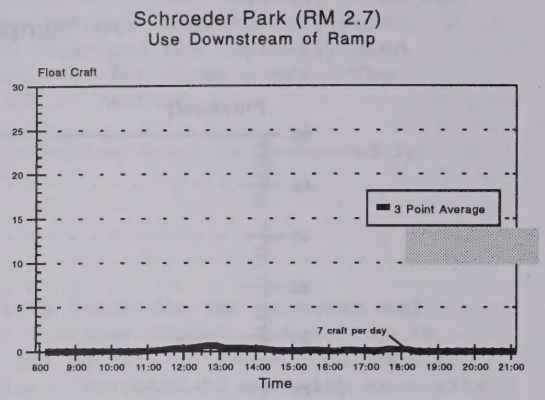
Average daily float craft for a weekday and a weekend day

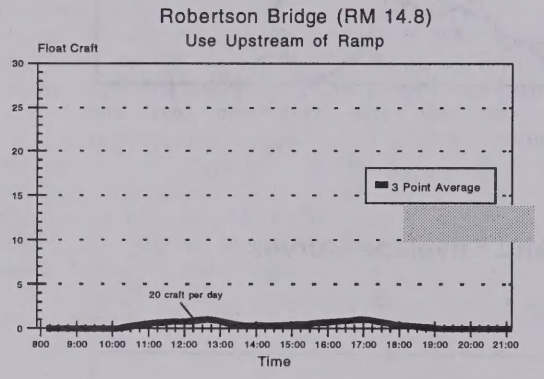
Figure 5

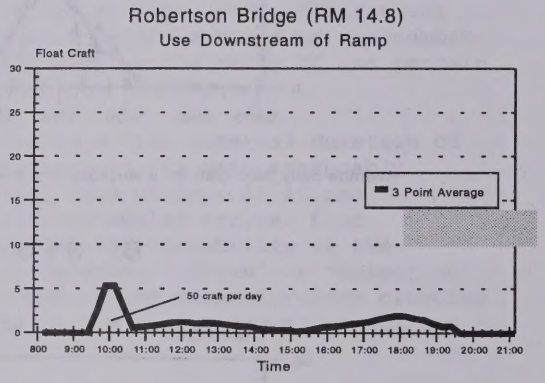
Sample Unit Use Curves
Hellgate Study Reach - Scenic Section

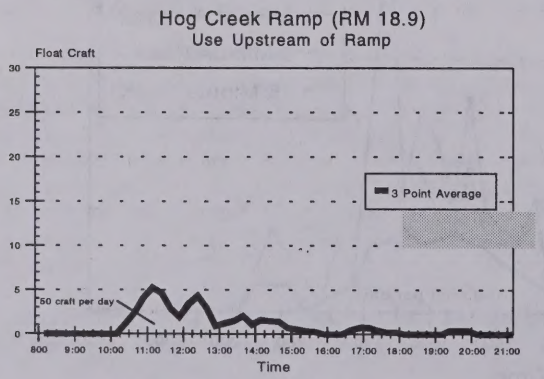
Expected FC per 15 minute interval











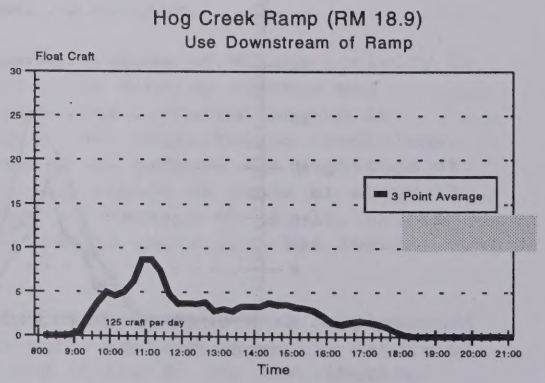
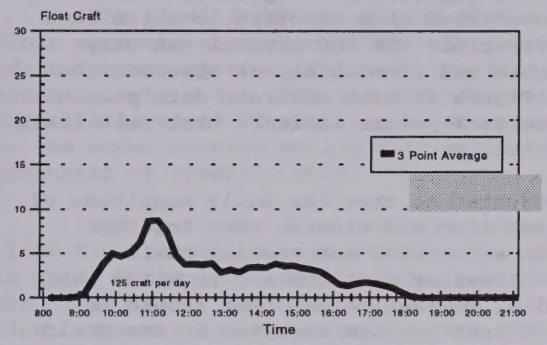


Figure 6

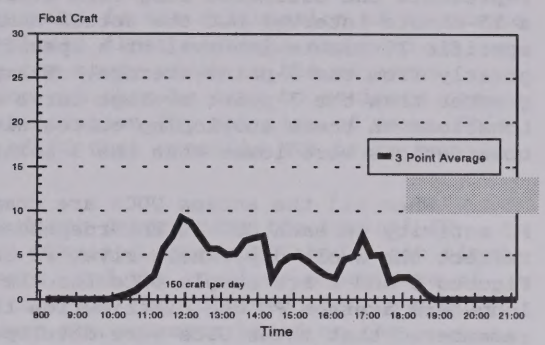
Sample Unit Use Curves
Hellgate Study Reach - Whitewater Section

Expected FC per 15 minute interval

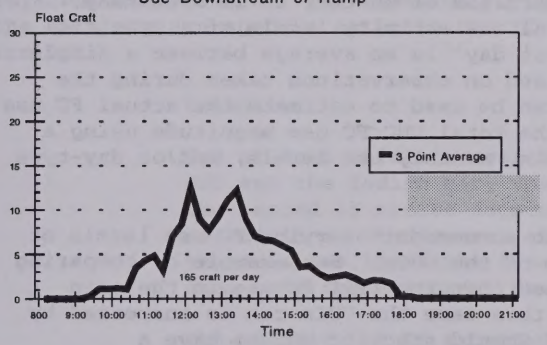
Hog Creek Ramp (RM 18.9)
Use Downstream of Ramp



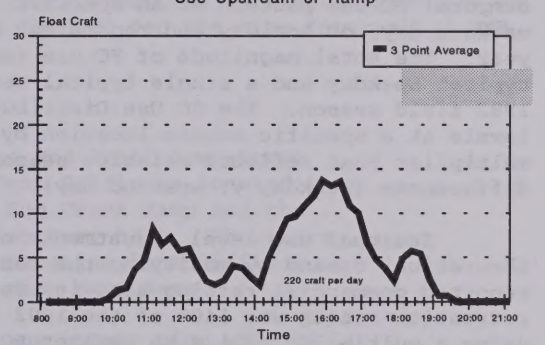
Galice Ramp (RM 25.7)
Use Upstream of Ramp



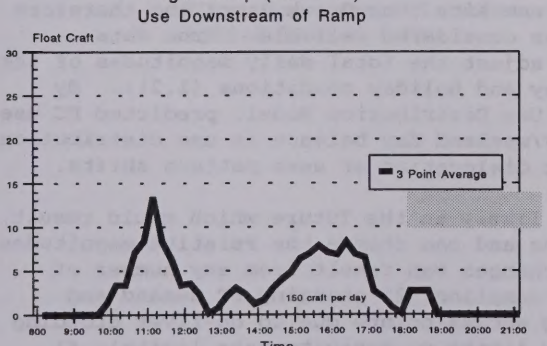
Galice Ramp (RM 25.7)
Use Downstream of Ramp



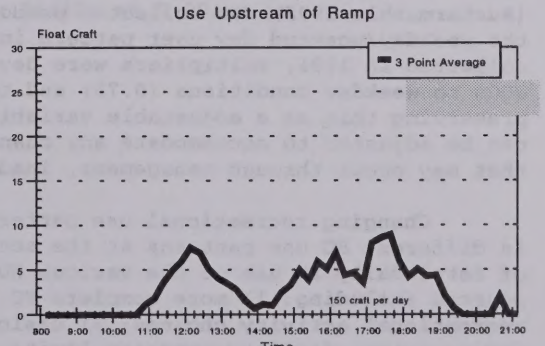
Argo Ramp (RM 31.4)
Use Upstream of Ramp



Argo Ramp (RM 31.4)
Use Downstream of Ramp



Grave Creek (RM 33.3)
Use Upstream of Ramp



Model to predict FC activity at SOCs is shown along with the highest magnitudes of FC use activity observed in specific time of day intervals. In the 1630 hr. interval, these curves indicate that peak activity observation was 37 FC in a single 15-minute interval and that all of that activity occurred in only one of the 5-minute intervals in that 15-minute interval. The 3-point average for the 1630 interval is about 7 FC. Therefore while 7 of the total daily 150 FC are expected in the 1630 hr. interval, the actual FC activity observed in the 1992 field season ranged from zero to 37 FC with many more low FC observations than high. As is the case with all the UUCs the 3-point average curve represents the estimated long-term average number of FC expected at a specific location in a 15-minute interval but the actual number of FC encountered at a specific location in a specific 15-minute interval of a specific day for a specific MTB SOC arrival can vary greatly from the 3-point average. Examples of 5-minute and 15-minute peak observations greater than the 3-point average curve are shown on Figure 4B with discrete data points. Locations on these enveloping curves without discrete data points indicate that peak field observations were lower than the 3-point curve.

When all the access UUCs are completed and adjusted so that the daily magnitude of FC activity on each UUC is interdependently consistent with all others, they together reflect the whole-day, whole-river FC user pattern on a temporal and spatial basis. Figures 5 and 6 are sample UUCs for the Scenic and Whitewater sections and show the basic long-term average FC use distribution through a typical recreation day. It should be remembered that these UUCs were developed from the FC user pattern observed in one field season on a limited number of sample days. A more thorough field data effort and/or a multi-year sampling program could result in significantly different UUCs.

C: Use Level Multiplier

The UUCs are termed "typical day" because a single UUC is used to portray the daily temporal FC use pattern at an specific location regardless of whether it is a weekday, weekend day, or holiday and regardless of the general use activity levels of a specific year. The total magnitude of FC use for the "typical day" is an average between a single typical weekday and a single typical weekend day based on observations taken during the 1992 field season. The FC Use Distribution Model can be used to estimate the actual FC use levels at a specific access location by adjusting the total UUC FC use magnitude using a multiplier that reflects relative seasonal use levels, monthly use levels, and/or day-type differences (weekday v. weekend day).

Seasonal use level adjustments can be used to accommodate varying FC use levels or theoretical demand by modifying the total magnitude of the UUCs. For example by comparing reported commercial rafting activity it was estimated that the 1991 FC use in the main recreation season was 140% of the 1992 levels. In this case the UUCs can be increased by using a multiplier of 1.4 to reflect FC uses 1991. Should specific months have a significantly different FC use level an appropriate multiplier can be used to integrate that factor into the UUCs and safety risk assessment (for example June, 0.85; July, 1.0; August, 1.2).

Since the UUCs reflect an average between a single typical weekday and a single typical weekend day a multiplier is needed to modify the magnitude of the typical day information to reflect weekend/weekday differences in FC use. The BLM's 1991 user data (Austermuehle 1992) was collected predominately at one site (Hog Creek Ramp) and therefore the weekday/weekend day user pattern information was considered reliable. From data collected in 1991, multipliers were developed that adjust the total daily magnitudes of the UUCs to weekday conditions (0.79) and to weekend day and holiday conditions (1.21). By preserving this as a adjustable variable in the FC Use Distribution Model, predicted FC use can be adjusted to accommodate any changing weekday/weekend day balance in use distribution that may occur through management, inadvertent user dislocation or user pattern shifts.

Changing recreational use patterns are very likely in the future which could result in different FC use patterns at the access locations and can change the relative magnitudes of total daily FC use of the various UUCs. These changes can result from any number of sources including: 1) more complete FC use pattern sampling; 2) changing FC demand and recreational activity choices; 3) dislocation among access points due to on-river crowding and/or access facility capacity limits (total daily limits or activity rate limits); 4)

dislocation among access points due to recreation management approaches; and, 5) the development of new and/or the closures of existing access points. Any changes in either the temporal FC pattern at access locations or changes in the relative magnitude of total daily FC uses among the access points will necessitate the modifications to UUCs that reflect the new conditions throughout the effected portion of the study reach.

D: 15-Minute Float Segments

The final component of the FC Use Distribution model is the delineation of 15-minute float segments throughout the study reach. These 15-minute float segments are used to identify the expected FC float time from any point in the study reach to the adjacent access points. The UUCs for the adjacent access points can then be used to estimate the expected level of FC activity at any specific on-river location for any time of day. This is the model process employed to estimate the number of FC that specific MTB trips may encounter at specific SOCs.

The 15-minute float segments were developed by first determining the typical FC float time between access points. The times used were obtained from published float times in guide books, information from informed on-river users, and the on-river experience of the field team. Between each access point the total time was then divided into 15-minute float segments and the segments were distributed between the accesses based on the distribution of swift and slow water.

To estimate the number of FC expected at a SOC when a MTB arrives, the time of MTB arrival is first identified and assigned to a 15-minute interval, then the number of 15-minute float segments to the adjacent upstream and downstream access points is determined. From the 15-minute interval of MTB arrival at the SOC, an appropriate number of 15-minute interval are shifted either forward or backward (as appropriate) in time on each of the two adjacent access UUCs. The expected FC use levels in those specified 15-minute intervals on the UUCs are averaged to estimate the FC use level at the SOC for the time interval of MTB arrival.

Example:

Use at Dunn Riffle is estimated from the Hog Creek downstream UUC and the Indian Mary upstream UUC. Dunn Riffle is located in the second 15-minute segment below the Hog Creek Ramp and the second 15-minute segment above the Indian Mary Ramp. Therefore there is one 15-minute float segment separating Dunn Riffle from both the Hog Creek Ramp and the Indian Mary Ramp.

The quantity of FC expected at Dunn at any chosen time will be a combination of FC that were at Hog Creek Ramp 15 minutes earlier and the FC that will be at Indian Mary 15 minutes later.

The estimated number of FC at Dunn Riffle at 1:00 pm will be the average of the number of FC at Hog Creek Ramp at 12:45 pm (3.75 FC) and the number of FC at Indian Mary at 1:15 pm (4.25 FC). The expected number of FC at Dunn Riffle at 1:00 pm is 3.75+4.25/2 = 4 FC.

IV: SOC ASSESSMENT

A: Introduction

This is the second of the three part BS/C risk probability modeling effort. Sites Of Concern (SOCs) are those locations where, due to limitations on MTB operations enforced by channel characteristics, inadvertent safety risk situations could develop. The SOC Assessment process was designed to develop a measure of "inherent safety risk" for each of the SOCs under the various modeling conditions (SOC/scenarios; each SOC for upstream and downstream operations and low and high flow conditions) and, based on channel, craft, and user pattern characteristics, to estimate potential safety risk and conflict parameters for each SOC/scenario over a range of hypothetical FC use levels. The SR/C Model (Chapter V) uses these FC use related safety risk and conflict parameters in conjunction with the estimated FC use levels from the FC Use Distribution Model (Chapter III) to predict safety risk and conflict conditions for specific recreation management scenarios.

There are two major parts to the SOC Assessment; 1) Single-FC Assessment, and 2) Multiple-FC Assessment. The Single-FC Assessment assumes that there is one FC in the SOC at the moment a MTB reaches the SOC and uses the basic MTB operational rules assumed in this BS/C Study to determine the likelihood that a potential accident situation would develop. The possibility that a potential accident situation will develop in any given SOC/scenario is determined using a fault-tree risk assessment procedures in which the MTB operator decision and MTB progression through a specific SOC is predicted from a set of prescribed situation/decision assumptions. The situation decision rules used in the fault-tree risk assessment are based on the assumed MTB and FC operational practices described in the following section.

The probability that potential accident situations develop when one FC is assumed to occupy the SOC is referred to in this BS/C Study as the "inherent safety risk" of a SOC/scenario. The products and results of the Single-FC assessment include: 1) the probability that the FC is not observed by the MTB operator at the start of the SOC, the Probability of Not being Seen (PNS); 2) the probability that if the FC is not observed and the MTB runs the SOC, there will be a MTB/FC encounter that exceeds safety margin tolerances, the Probability of Safety Risk (PSR); and, 3) the probability of a MTB/FC encounter occurring that exceeds the safety margin tolerances when one FC is in the SOC (the PNS times the PSR), the Probability of a Mutual Occupation (PMO). The PMO describes the probability for the inadvertent development of potential accident situations (Mutual Occupation incident: MO) and the "inherent safety risk" of the SOC/scenario.

The second major part is the extension of the single FC analysis to the situations where multiple (0-50) FC occupy porions of the SOC over a 15 minute time period and <u>may</u> be involved in MTB/FC encounters at SOCs. The encounters that could occur over the possible FC use level range are assessed in this part for: 1) safety risk potential; and, 2) conflict potential. Safety risks are defined in this BS/C Study as occurring when no FC are observed in the SOC and, upon MTB run initiation, MTB/FC encounters occur in the SOC in situations that exceed acceptable safety margin tolerances. Safety related conflicts are defined by the frequencies and duration of wait incidents that occur at SOCs when the FC are observed to be occupying the SOC.

The Single-FC Assessment is extended to the Multi-FC Assessment by first, for any given FC use level (0-50 FC per 15-minute period), determining the likelihood that the SOC is occupied by at least one FC, the Probability of Rapid Occupation (PRO). The PRO is used to determine the number of FC that would be in the SOC at the time of MTB arrival. The PRO along with the PNS and PSR developed in the Single-FC SOC Assessments are used to develop measures of safety risk and conflict over the range of hypothetical FC use levels. For a particular recreation management scenario, the SR/C Model uses the FC Use Distribution Model to identify the number of FC that are likely to be at a specific SOC for a specific MTB trip arrival time and uses the PMO and wait incident information derived in the Multi-FC Assessment step to predict probable levels of safety risk and conflict.

This chapter presents: 1) the functional definitions and assumptions developed to provide the conceptual framework for assessing the "inherent safety risk" at the SOCs; 2) the methodological approaches to the Single-FC and Multi-FC Assessment procedures; and, 3) the resulting safety risk parameters developed for the SOC of the Hellgate Study Reach and the Gold Hill Study Reach.

Due to the pressing BS/C concerns on the Hellgate Study Reach this portion of the Rogue River BS/C Study Area received the majority of the field work attention. More than 140 field and sample days were expended on this study reach collecting user pattern information, tracking MTB and pvt-JB activities, and developing channel characteristics. Conversely only about 12 field and sample days were expended on the Gold Hill Study Reach. As a result of these data collection efforts the use and user data base developed on the Hellgate Study Reach was sufficient to proceed through the quantitative and probabilistic BS/C safety risk modeling procedures developed in the BS/C Study. This includes the FC Use Distribution Model and SOC Assessments that result in probability estimates of various safety risk parameters. With the FC Use Distribution Model and the probabilistic SOC Assessments, the SR/C Model procedures can be used to develop estimates of safety risk exposure for a variety of recreation and management scenarios on the Hellgate Study Reach. However, on the Gold Hill Study Reach the use and user data base was inadequate for appropriate use in a formal probabilistic modeling assessment approach.

The treatment of SOC Assessments in this chapter is divided into four parts to accommodate the varying use and user data bases developed on the two study reaches and the resulting SOC Assessment approaches undertaken to accommodate the data.

Part I provides general background on the SOC Assessment approaches and includes the functional definitions and assumptions developed to provide the conceptual framework for assessing the "inherent safety risk", and the basic fault-tree risk assessment approach used to route a lead MTB through each SOC to determine elements of potential safety risks and conflicts.

Part II addresses the methodological approaches to the Single-FC and Multi-FC Assessment procedures and applies the SOC Assessment procedures as developed in the BS/C Study to the Hellgate Study Reach SOCs. Table 2 presents safety risk parameters for the Hellgate SOCs developed from the assessment procedures and Plates 2-66 in Appendix J show the development of the Single-FC SOC Assessments for each SOC/Scenario. Example Multi-FC SOC Assessment results for the Hellgate Study Reach are presented in Figures 29 and 30.

Part III addresses the SOC Assessment for the Gold Hill Study Reach SOCs. Because of inadequate data bases, the full application of the SOC Assessment procedures as developed in this BS/C Study were not applicable, therefore the Gold Hill SOCs were treated in a more qualitative manner. The results of the fault-tree risk assessments for each of the SOC/scenarios on the Gold Hill Study Reach are found on Plates 67-74 in Appendix J.

Part IV presents example SOC/scenario Plates for the SOCs of the study area.

PART I: BACKGROUND

B: Functional Definitions and Assumptions

In order to develop and execute a risk probability model for BS/C issues, the "inherent safety risk" aspects of SOCs for the various operational and flow condition scenarios, must be assessed using assumptions that structure the procedures. The definitions and assumptions presented below are those used to define the SOC/scenarios and to limit the nearly infinite array of MTB and FC operator behavioral possibilities that could occur in every possible situation to those that can be used to generate reliable safety risk modeling results.

1) Safety Risks:

Through the FG process four basic parameters were developed to define "safety risks" in this BS/C Study and to structure the BS/C risk assessment. These parameters are: 1) user activity types involved; 2) the potential severity of accidents; 3) the potential for accident situations; and, 4) the degree of control over the potential accident situation. (See Appendix K; Focus Group Meeting Notes, 32-40 and 42-9)

The FG members adopted the general definition that safety was the absence of risk. They also recognized that risk, and therefore safety risk, is inherent in many of life's activities including the recreational uses of rivers. A clearly stated contention from most, if not all, FG members was that most accidents that occur on Hellgate Study Reach in recent years have been self-induced or result from the activities of others in the same activity group. Cited examples were bed and bank users falling on wet rocks or unstable bed and/or bank material, FC users flipping and/or swimming as a result of poor operator skills, and FC congestion at rapids causing problems in negotiation of the rapid, etc. Many of the FG members also stated that safety risk conditions were increased by various user activity patterns that include alcohol consumption, lack of safety equipment and knowledge of its proper use, misuse of PFDs, poor skill, and poor education in river etiquette.

The FG recognized the premise of implied safety risk which means in concept that those who undertake river recreational activities understand the potential risks of their activities and, so long as the element of safety risk is a result of user/environmental circumstances, they accept the risks and liabilities associated with those activities and assume the responsibilities. Those accidents and safety risks that are associated with specific activities, and the possible accident outcomes of those activities were assumed to be the responsibility of the users. Rafters injured or rafts damaged in the coarse of a river trip as a result of flipping in a rapid or broaching on a rock are part of the implied safety risk of the activity and are not part of the BS/C issues of this study. The same would apply to anglers who slip on cobbles, etc., and other recreational activities. The concept of implied safety risk also extends to incidents that may result from the interaction between users of the same activity type, for example, raft congestion at a rapid causing accidents.

Issues of safety risk addressed in this BS/C Study were limited by the FG members to those associated with incidents involving different and potentially conflicting activity types. Potential inter-activity safety risks were the risks induced by the actions of other users and user types and were not included within the conceptual boundaries of implied safety risks. The safety risks to be addressed were those that result from the interaction of different activity types and where the safety risks were not simply associated with those inherent in the individual activities themselves. Further, the cosponsoring agencies identified the main interest of the BS/C Study to be concerned with motorized v. non-motorized recreational activity issues. As a result of the FG process, the issues to be addressed by the BS/C Study were limited to those associated with the interaction of motorized boating and the other recreational activities in the study area.

Accidents or potential accident incidents of concern were defined by the FG to be those that could result in equipment damage, personal injury, or loss of life. The FG recognized that accidents involving MTBs passing bed and bank users could as easily result in equipment damage as injury while those involving FC could as easily result in equipment damage, injury, or loss of life. The specific outcome severity of a particular accident is largely driven by specific circumstances of apparently minor dimension, such as a 2 ft. difference in location, etc., where small variations in the situation can result in outcomes ranging from minor equipment damage to loss of life. Accident situations were considered in this BS/C Study as having equal safety risk significance and that any circumstance that could result in any of the stated outcomes were considered by the FG as safety risk situations to be addressed by the study.

The third element of safety risk is the consideration of potential accidents. There was basic disagreement among members of the FG on the point of the likelihood for actual accidents. Some FC and driftboat members of the FG felt that accidents between JBs and other users were possible, and even likely, in most river settings while other FC and driftboat users, and the JB operator members of the FG thought that JB control could be

effectively used to avoid actual accidents even when craft separation was extremely small. In recognition of the potentially dramatic variation of incident outcome based on minor and often unpredictable conditions (see preceding paragraph), the FG agreed to the concept that even though an accident is defined to occur only when an encounter leads to equipment damage, personal injury, or the loss of life, potential accident situations can be defined as occurring when craft separation distances are less than some threshold value. The thresholds for acceptable separation distance would vary with channel hydraulic conditions and the operational mode of the JB involved. The FG agreed to the definition of safety risk situations as those circumstances in which craft separation distances are less than the adopted craft separation threshold distances. When these thresholds are exceeded there is the potential for encounters to develop into accidents as accidents are defined above.

The fourth element of safety risk is the degree of control over potential accident circumstances. The members of the FG generally agreed that accidents, that meet the above severity tests, could occur at any location in the study area. Given a poor enough JB operator, poor enough relations between on-river users, poor judgment, operator error, or possibly even an equipment malfunction, a JB could overrun other users in the best of channel conditions and circumstances. An evaluation that considered all of these potential circumstances would not provide risk assessment results that would be useful in categorizing the safety risks that may be unique to the study area. To accommodate this issue the FG agreed that those elements that met the conditions of safety risk circumstances (see above points) would also have to occur in situations that were above and beyond the control of users and operators before a safety risk condition, as defined in this BS/C Study, would occur. The FG recognized that many other accident scenarios could also create safety risk situations but these were understood to be common to all river settings involving similar recreational activity types. These potential accident scenarios that are not unique to the study area were not considered in the BS/C Study.

In this BS/C Study "safety risks" and "safety risk situations" were defined to exist when all four of the following conditions exist:

1) the incident involves encounters between JBs and non-motorized water recreation activities,
2) there is the potential for equipment damage, personal injury, or loss of life as a result of the encounter,
3) craft separation exceeds specific threshold distances, and
4) when (3) above, occurs under the best of operational circumstances.

Under the definition presented above, situations that lack any one of the four circumstances was not considered a safety risk issue in this BS/C Study. Accidents and potential accident conditions could occur in circumstances that lack safety risks (as defined here) but they would be related to such things as inappropriate craft operations, poor operator judgement and/or skill, operating with less then optimal safety prudence, intentionally induced risks, and equipment failures, etc. While these conditions can certainly lead to safety risks and accidents, they are not unique to the study area, nor to any location in the study area, and were therefore not addressed as concerns in the SOC Assessment and BS/C risk probability modeling effort. These issues do however, present real and/or perceived safety risks and can add to the safety risk conditions of the study area. They are addressed in the Boating Safety and Conflict Problems chapter using a non-modeling approach.

2) Acceptable Risks:

Acceptable risk was defined as that level of risk exposure or potential that is acceptable with respect to degree of risk possibility, degree of risk severity, and with respect to the economic, social, resource, and/or other values associated with the activity that created the risk. The resource value side of the acceptable risk equation involves many aspects of the recreational environment far beyond those addressed by safety risk which may include the tradeoff between loss of access or freedom of action required to reduce safety risks. In the case of the Rogue River BS/C study area the values associated with the defined safety risk (see above) includes among others, access and visitation to the river for individuals that can only use motorized craft, economic values to the employees of the MTB operation, and secondary economic benefits to the local area. In this

BS/C Study no effort was made to define an appropriate level of acceptable risk. This issue may be addressed during the BLM's RAMP process. (See Appendix K, 38)

3) Sites of Concern (SOC):

The SOCs for each study reach were identified through a process of field review and aerial photo review of MTB navigational/operational options and line-of-sight (LOS) limitations. All the rapids and riffles with limited navigational/operational options and visibility limitations were reviewed. Rapids/riffles with unseen channel portions between MTB set-down areas were defined as SOCs. Also included were some rapids and riffles that had no sight limitations but which had set-down threshold and line of sight geometry that indicated there could be circumstances that may limit the MTBs ability to accommodate FC.

4) SOC Limits:

An important element in the whole BS/C probability modeling effort was determining the probably number of FC in the SOCs (PRO, see above) for any given FC use level. The PRO was derived from the number of FC predicted to occupy a 15-minute float segment in any prescribed 15-minute interval (from the FC Use Distribution Model) and the average FC float time in the SOC relative to the 15-minute float segment. Therefore it was important to establish precisely the size of, and the boundaries for, each SOC/scenario.

The methods used to define the boundaries of a SOC varied slightly for downstream and upstream MTB operational directions:

Downstream MTB Operations; The upstream boundary, the Run Initiation Point (RIP), was the location at which the MTB could no longer be stopped safely from an on-plane operational mode, and was committed to running the SOC. The downstream boundary, the Safety Threshold (ST), was defined as the point at which a MTB could be safely stopped from an on-plane operational mode plus a safe craft separation distance.

Upstream MTB Operations; The downstream boundary, the RIP, was the location at which the MTB could no longer be stopped safely from an on-plane operational mode and was committed to running the SOC. The upstream boundary was defined as the point at which a MTB could be safely stopped from an on-plane operational mode (the ST), plus a safe craft separation distance [SSD] below), plus a distance upstream over which the fastest FC could float and encroach into the SSD during the MTB run time through the SOC.

5) Inadvertent Mutual Occupation:

The overall conceptual approach to the BS/C probability model was based on estimating the probability that MTB/FC encounters will occur in portions of SOCs in situations in which safety thresholds were exceeded even under the best of conditions. This approach was based on MTB and FC use pattern characteristics observed in 1992, craft operational characteristics, and channel and streamflow characteristics, etc. The approach uses the assumption of "best" MTB operational practices as a premise for separating "inherent safety risks" from those that may be operator induced. The assumed "best" MTB operational practices are addressed below. Circumstances in which MTB/FC encounters occur in SOCs at less than acceptable craft separation distance, even when best MTB operational practices are used, were termed inadvertent Mutual Occupations (MOs). The measure of the likelihood for MOs occurring at a SOC under specific circumstances was referred to as the Probability of Mutual Occupation (PMO). The PMO results of the Single-FC Assessment procedure is a measure of the "inherent safety risk" of the SOC/scenario.

In this BS/C Study a MO was an unavoidable and inadvertent safety risk incident in which there was the potential for accidents to occur which are serious enough that they could result in loss of life, personal injury, and/or equipment damage. Therefore the SOC Assessment step provides estimates of the occurrence of unavoidable potential accident situations not: 1) avoidable potential accident situations; nor, 2) actual accidents. MOs are the basis of the safety risk estimates in this BS/C Study. Avoidable potential

accident situations in MTB/FC encounters that exceed the adopted safe craft separation thresholds (termed Overt MOs in this BS/C Study) occur when less than "best" MTB operational practices are used. These could occur in either SOCs or on non-SOC sections of the river.

The modeling prediction of actual accidents was far beyond the capabilities of a probability modeling approach. The prediction of actual accident occurrences would depend on the prediction of potential accident situations (as this BS/C modeling approach uses), plus, among other issues: 1) the precise location of each and every FC in each potential accident location and for each and every MTB/FC encounter situation; 2) the speeds of all FC; 3) the actual response pattern of each FC user in a specific potential accident situation; 4) the precise speed, location, and craft attitude of the MTB when the potential accident situation was discerned by the operator; 5) the maneuvering and stopping characteristics of the specific MTB craft in each potential accident situation; 6) the experience, skill level, judgement making, and fatigue characteristics of the MTB operator at the moment of the incident; and, 7) the actual evasive maneuvers undertaken by the MTB operator.

MOs are incidents of inadvertent safety risk exposure that are idiosyncratic to the study area resulting from channel, craft and user patterns characteristics. Predicted MOs are the basis of the safety risk exposure evaluation in the study area and the basis of comparing the safety risk outcomes of various conditions and management schemes.

6) MTB Physical Stopping Distances:

The ability for MTBs to stop prior to or during emergency situations was determined to be the key BS/C MTB operational characteristic. Each MTB craft is likely to have stopping characteristics slightly different from other MTBs, and during each emergency situation each MTB is likely have varying stopping performance characteristics based on total load, load distribution, and speed. The craft characteristics that determine the stopping performance include: 1) total horsepower; 2) number, type, and size of jet-drives; 3) hull configuration including width, length, and prow shape, etc.; 4) weight and inertia at different speeds; and, 5) weight distribution considering engines, hull, and load. As a result not only would each of the different MTBs in the study area likely have different stopping distances but these stopping distances could vary from trip to trip depending on loads and operator skill, and would vary with the particular operating speed and craft attitude at the time the stop maneuver is initiated.

To accommodate these variables, stop tests were conducted on "Medium" and "Large" sized MTBs operating on the Rogue River outside the BS/C study area (See Appendix D for details). During the stop test runs, the MTB operators of nearly fully loaded craft executed straight-line stops using the most aggressive methods they could employ without endangering their passengers. Figure 7 is a 32 ft. "Medium" sized MTB in a stop test run showing the bow spray generated when the bow is buried by the reversed jets. From these tests "typical" physical stopping distances (PSDs) were determined. PSDs were based on straight-line MTB stopping procedures so that a conservative minimum distance requirement could be established. It is recognized that shorter stopping distances are possible in emergencies but they may put the MTB passengers and/or MTB craft at risk and may not be possible if there are multiple FC to be avoided or there are navigational limitations. Situations deemed safe using the straight-line stopping distances should be safe regardless of the specific channel characteristics and number of FC involved.

Distances to both achieve a drifting attitude and a full stop were determined for both these MTB size classes for an assumed approach speed of 25 mph. For the Hellgate Study Reach the PSDs used for evaluating BS/C concerns were those for the "Medium" sized MTBs which were derived from the "Medium" sized MTBs on the Lower Rogue. While similar in size and load capacity to the "Medium" sized MTBs on the Hellgate Study Reach, the Lower Rogue River MTBs have more drive trains and greater total horsepower and, therefore, could have shorter PSDs. The Hellgate Study Reach "Medium" sized MTBs presently in use are the three "Argo" type craft. The PSD sample size for the "Large" sized MTBs was too small to be used reliably to estimate PSDs for the "Large" sized MTBs in use on the Hellgate Study Reach. The PSDs for the "Large" MTBs could be substantially longer than for the "Medium"

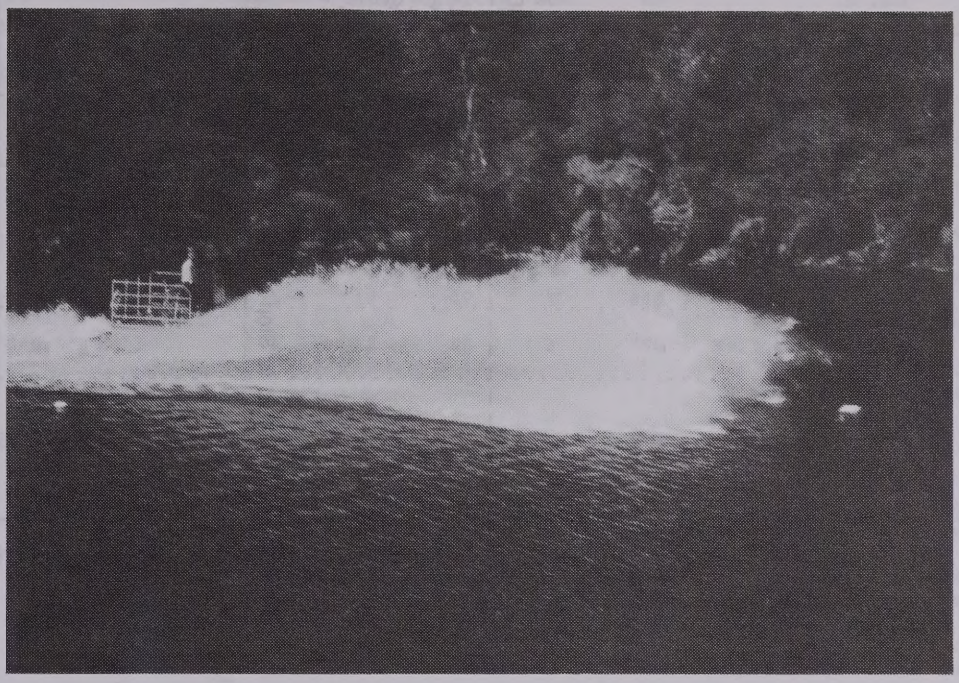


Figure 7

MTB STOP TEST

Photograph of a 32 ft. "Medium" sized MTB on a stop test run. At this point the MTB has traversed about 1/2 boat length and is still bow-down with fully reversed thrusting jets. The floats in the foreground are markers along the stop test course used for measuring distances.

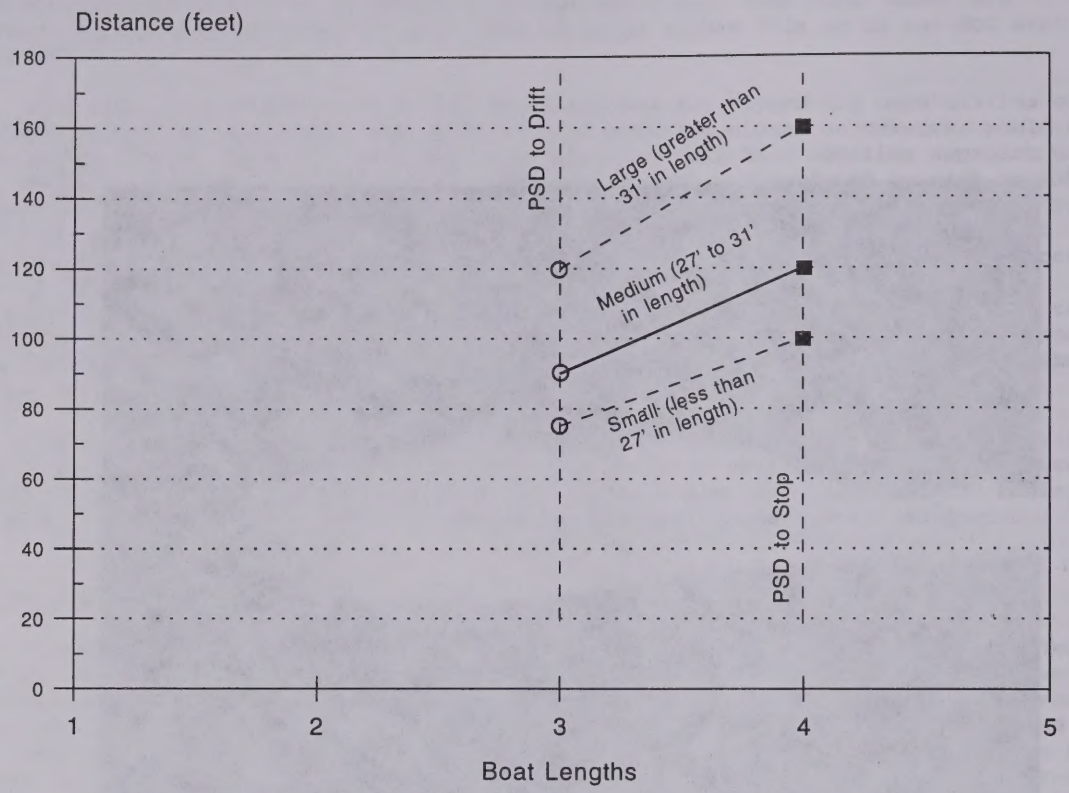


Figure 8

ASSUMED MTB PHYSICAL STOPPING DISTANCES
Rogue River Study Area

These estimated Physical Stopping Distances (PSDs) are based on off-site stop tests conducted on MTBs similar to the "Medium" sized MTBs used on the Hellgate Study Reach. In the stop tests, "PSDs to drift" were measured from the nose of the MTB at the point of first noticeable change in attitude of the on-plane craft to the nose of the craft when it achieved an off-plane, slow speed, even keel, shallow draft attitude (drifting). The "PSDs to stop" were measured to the nose of the craft at the point a complete stop was achieved. Approach speed variations resulted in varying PSDs and an approach speed/PSD relationship was established (See Appendix D). An approach speed of 25 mph was assumed as a standard for PSDs to set SSDs in the SOC Assessments. The measured PSDs to drift and to stop in feet for "Medium" sized MTBs at 25 mph were identified from the approach speed/PSD relationship and converted to "boat lengths"; 3 and 4 respectively. Estimated PSDs to drift and to stop for "Large" and "Small" sized MTBs were developed based on boat length relationships (3 and 4 respectively) and converted to distances in feet using an assumed standard hull length for these craft types (40' and 25' respectively).

Table 1

MOTORIZED TOUR BOAT CRAFT CHARACTERISTICS
Rogue River Study Area

MTBs in use 1991 - 1993

MTBs by Size Categories	Hull Length (ft.)\1	Hull Width (ft.)\1	Pass. Cap.\2	Eng. Num.	Total HP	Reach in use
Large MTBs:						
Miss Grants Pass	42	14	82	3	960	Hellgate Study Reach Scenic Section
Ginni Mac	42	14	71	3	960	Hellgate Study Reach Scenic Section
Glen Wooldridge	35	12	49	3	640	Hellgate Study Reach Scenic Section
Heidi Jo	35	12	49	3	640	Hellgate Study Reach Scenic Section
Wendy Marie	35	12	49	2	640	Hellgate Study Reach Scenic Section
Zane Grey \3	32	12	43	3	960	Hellgate Study Reach Scenic Section Whitewater Section
Medium MTBs:						
Argo	30	11	42	2	680	Hellgate Study Reach Scenic Section Whitewater Section
Osprey II	30	11	43	2	680	Hellgate Study Reach Scenic Section Whitewater Section
Miss Hellgate	30	11	36	2	640	Hellgate Study Reach Scenic Section Whitewater Section
Small MTBs:						
Miss Rogue River* \4	30	9	26	2	660	Gold Hill Study Reach
City of Rogue River	26	6	17	1	330	Gold Hill Study Reach
Miss Galice*	26	9	17	1	320	Hellgate Study Reach Scenic Section Whitewater Section
White Horse*	25	8	21	1	320	Hellgate Study Reach Scenic Section Whitewater Section
Miss Woodville	22	6	13	1	330	Gold Hill Study Reach
Example Medium MTBs used in stop tests:						
John Adams \5	32	12	42	3	1080	Lower Rogue River
Chinook \5	32	12	42	3	1020	Lower Rogue River

Notes:
\1 MTB hull dimensions rounded to nearest foot.
\2 Passenger Capacity is the total number of persons; passengers and crew.
\3 Considered a "Large" sized MTB because of poor weight distribution.
\4 Tentatively considered a "Small" sized MTB due to low capacity and relatively high inferred power to weight ratio; should be field tested to confirm.
\5 Considered a "Medium" sized MTB due to high HP and relatively high inferred power to weight ratio.
*/ Not observed in operation during the 1992 field season.
Sources: Walker and Austermuehle 1994, for the Hellgate Study Reach MTBs; Randy Cort, owner/operator Jet Boat River Excursions, for the Gold Hill Study Reach MTBs; and for the Lower Rogue River MTBs, Bill McNair, owner/operator Jerry's Rogue Jets and Ed Kammer owner/operator, Rogue River Mail Boat Trips.

sized MTBs. "Small" sized MTBs, like those in use on the Gold Hill Study Reach, were assumed to have PSD relationships similar to those of the "Medium," sized MTBs based on relative boat length (See Figure 8).

These PSDs at 25 mph were used as the basis of determining the MTB safe stopping distances. Actual PSDs of the MTBs in use on the Hellgate Study Reach could be substantially longer if the assumed "Medium" sized MTB PSDs are too short, MTBs are operated at speeds greater than 25 mph, or "Large" sized MTBs are used.

7) Safe Craft Separation Thresholds:

MOs were defined to occur when a MTB can not be operated to maintain an appropriate separation distance between itself and a FC within a SOC. Safe craft separation distance thresholds can also be exceeded in non-SOC sections of the river and would also be considered as potential accident situations. However, because potential accident situations in non-SOC areas were defined as avoidable, they were termed an Overt MO and not included in the risk model. Safe craft separation thresholds and the assumed craft separation distances that define potential accident situations vary with MTB operational direction, MTB operational mode, and channel hydraulic intensity.

During off-plane MTB operations, in-line (when craft are closing) safe craft separation was determined to be one MTB boat length when operating downstream and 1 1/2 boat lengths when operating upstream. For the Hellgate Study Reach using "Medium" sized MTBs, these distances are 30 and 45 ft. respectively and on the Gold Hill Study Reach using "Small" sized MTBs they are 25 and 40 ft. respectively. If "Large" sized MTBs were modeled on the Hellgate Study Reach these distances would be 40 and 60 ft. respectively. MTB craft length was used as a parameter for craft separation because both the MTB footprint width and off-plane maneuverability were assumed to be related to length and weight. In these set-down situations larger MTBs can be slower and more cumbersome in responding to FC float trajectories. The greater thresholds for craft separation distances for larger MTBs provides more time and room for MTBs and FC to avoid each other.

When MTBs are off-plane and craft are passing each other the assumed safe craft separation distance was a function of MTB operational direction, hydraulic turbulence, and the predictability of FC float directions. During downstream operations any off-plane MTB passing FC in the same channel areas of a SOC was considered a MO. During upstream operations in quiet set-down areas, where water velocities are low and the float lines of FC are reasonably predictable, safe craft separation distances were assumed to be the width of the MTB. In this hydraulic situation it was assumed that FC can be easily maneuvered to avoid a stopped MTB. Set-down areas such as these need to have a minimum width to allow for MTB/FC passes without inducing MOs. This minimum set-down width was assumed to be five MTB boat widths: one for the MTB itself, two more to allow the safe craft separation for FC passing on each side of the MTB, and two more that provide for the space occupied by both FC and the necessary separation between the FC and the edge of the set-down area. On the Hellgate Study Reach, the SOC Assessment based on the "Medium" sized MTBs, 55 ft. was minimum quiet set-down area width that allows passes without MOs; on the Gold Hill Study Reach this would be about 45 ft. If "Large" sized MTBs were modeled on the Hellgate Study Reach a 70 ft. wide set-down area would be needed.

MOs can also be avoided when upstream operating MTBs are stopped when the float routes of the FC would typically by-pass the position of the stopped MTB. When the set-down area has swift water and a degree of turbulence that creates uncertainty in FC float trajectory and a situation where FC have the possibility of floating into the MTB, all FC float-bys were considered as MO situations. These set-down areas were generally in channel locations where streamflow is highly concentrated and narrow enough that the effective set-down area width does not exceed the width requirement for quiet set-downs. Professional field judgement by WRC was used to discriminate the hydraulic conditions of set-down areas into the two types.

Safe craft separation thresholds during on-plane operational modes depend on basic channel conditions. In non-SOC areas on-plane safe separation distances were assumed to be 40 ft. This parameter was derived from FG member input (See Appendix K). Therefore to accommodate multiple-FC situations, effective channel (that portion of the channel used by

MTBs and FC) widths in non-SOC areas would have to be at least 80 ft. wide plus the MTB craft width, plus the FC footprints and some effective channel area between the FC and the edge of the channel. In SOCs, all on-plane passes were considered as MO situations so long as the FC and MTB were using the same route and that the route is physically defined by rocks etc. that prevent any chance of FC moving from a non-MTB route to the MTB route during the MTB run.

8) MTB Safe Stopping Distances:

Typical MTB Safe Stopping Distances (SSDs) were determined to establish the minimum size of usable set-down areas, critical MTB operator decision points, and safety thresholds in SOCs . These distances were based on the assumed PSDs of the "Medium" sized MTBs from the Lower Rogue River. SSDs for a variety of situations and for both upstream and downstream operational directions were developed (See Appendix E for details).

The SSDs modify the PSDs by adding operator decision reaction time, the footprint of the MTB at the moment the stopping maneuver is initiated, and the appropriate safe craft separation distances. These factors were not included in the PSDs, and safe craft separation distances, etc. On the Hellgate Study Reach the SSDs employed (Figure 9) were for the "Medium" sized MTBs only: if the "Large" sized MTBs were to be modeled the SSDs could be substantially larger. The SSDs for the "Small" sized MTBs in use on the Gold Hill Study Reach were determined from the "Medium" sized MTB SSDs and modified on the basis of boat length relationships (See Figure 10).

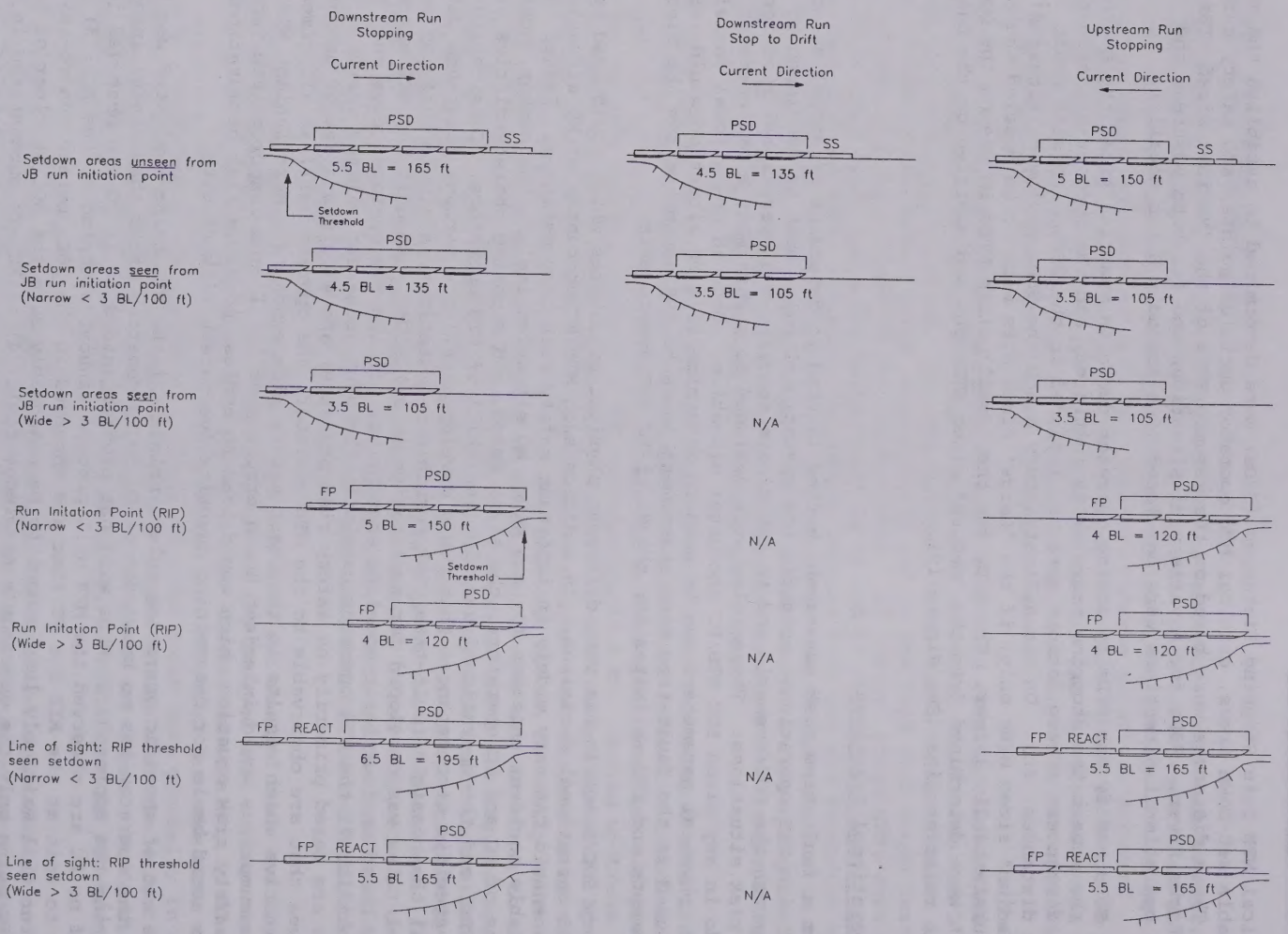
9) MTB Operational Practices:

When a fault-tree risk assessment method is used to determine potential safety risks associated with MTB operations, specific MTB operational rules must be developed to guide the MTB through the SOC/scenario and to anticipate specific MTB operational reaction to potential risk situations. These rules were designed to govern what a MTB operator would chose to do in any given SOC MTB/FC encounter situation. Once an operational decision was determined, physical parameters can be used to determine if a MO situation would result. The rules used in the fault-tree risk assessment leads to PSR estimates for the Single-FC SOC Assessments and PMO estimates for the Multi-FC SOC Assessments.

Every SOC/scenario has very different physical attributes which could lead to varying MTB operational decisions. In addition each MTB/FC encounter or MO situation in each SOC/scenario can vary widely in important safety risk circumstances. Issues that may drive variable accident outcomes for any given MO situation include the number, position, and actions of FC and FC operators, the size, speed, and stopping characteristics of the various MTBs, and the operational decision and skill of MTB operators. Considering all the situation-specific circumstances that could develop at all the various locations within a SOC and all the possible fault-tree risk possible permutations, a single unifying set of operational rules was developed for application in all SOCs. The unifying MTB operational rules were based on four basic modeling assumptions: 1) the MTB operator uses only the best possible skills; 2) the MTB operator uses only the best judgement; 3) the operational judgements are based primarily on safety risk prudence; and 4) given a set of operational alternatives that are observable to the MTB operator, the operator will at all times select that alternative which results in the least safety risk exposure. More lenient MTB operator assumptions would interject human error, poor skill, and inappropriate judgement into the safety risk equation which would lead to endless possible risk permutations and provide no sound basis for determining quantitative safety risk results.

The set of specific operating rules include: 1) the MTB being evaluated was the lead craft and the operator has no knowledge of FC SOC occupation other than visual information gained during the approach; 2) MTBs will not proceed into SOCs if FC are observed in the SOC; 2) if no FC are observed the MTB will proceed without stopping at the RIP; 3) if the MTB stops to wait at the RIP for FC that are observed in the SOC, before run re-initiation the operator will wait only long enough to be reasonably sure the SOC is clear of the observed FC using only the operator's knowledge field; 4) if FC are encountered in the SOC, the MTB will either stop at the first available location or change to a drifting attitude if possible, which ever imparts less safety risk.

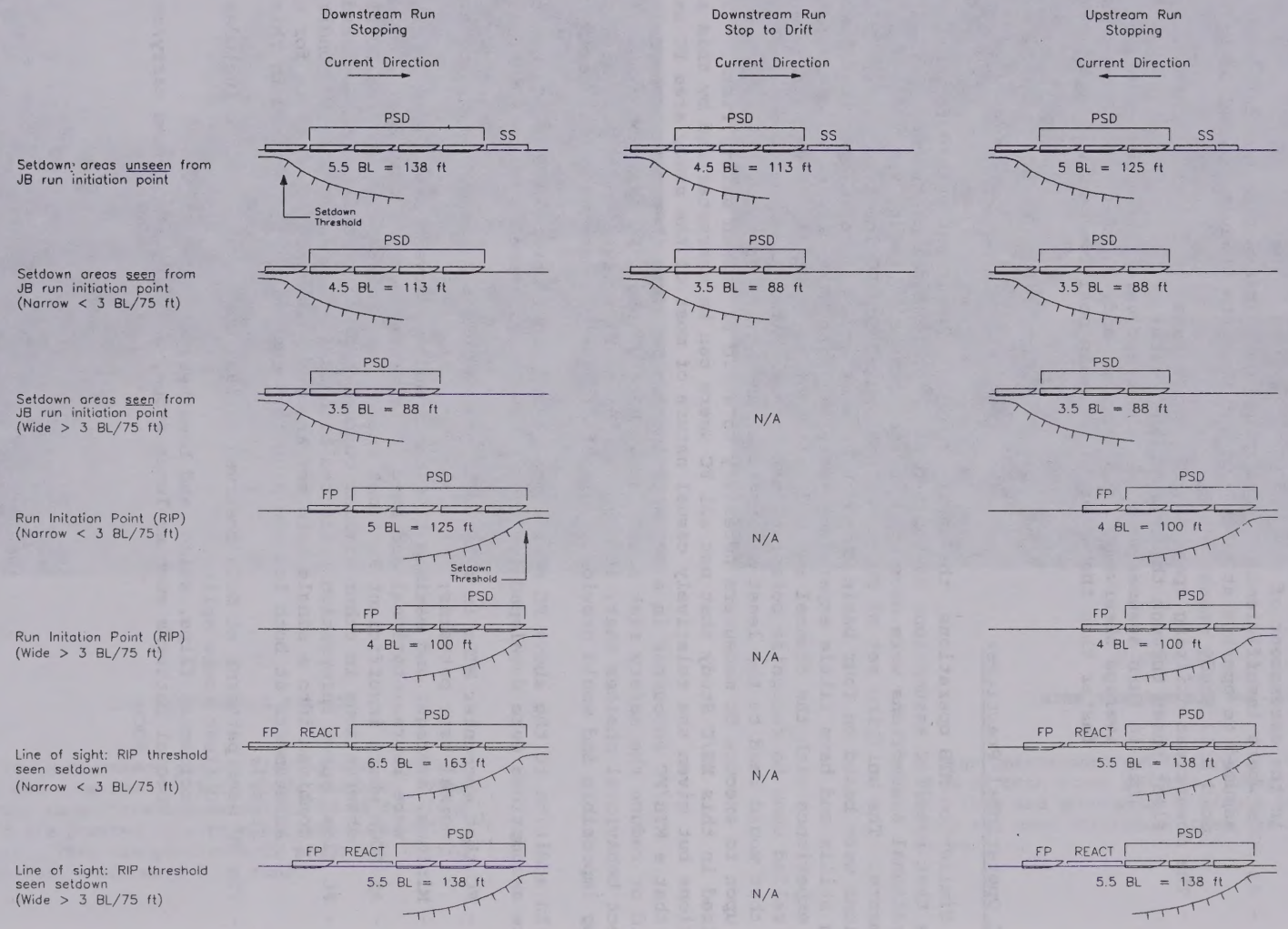
Figure 9
Estimated MTB Safe Stopping Distance
Hellgate Study Reach
Medium Size MTBs (27' to 31' in length)



Legend: PSD = Physical Stopping Distance
SS = Safe Separation
FP = Boat Footprint

React = Reaction Time (1 sec = 45 ft)
BL = Boat Length (Assumed 30')

Figure 10
Estimated MTB Safe Stopping Distance
Gold Hill Study Reach
MTBs less than 27' in length



Legend: PSD = Physical Stopping Distance
SS = Safe Separation
FP = Boat Footprint

React = Reaction Time (1 sec = 38 ft)
BL = Boat Length (Assumed 25')

In addition to these operational rules that were applied to MTB operator decision making, several other MTB operational assumptions were developed for use in the SOC Assessments:

- All consistent MTB stops at the entrances to SOCs observed in 1992 were used as an observed condition in the assessments, if inconsistencies were observed the shortest stop time was used;
- The average on-plane MTB operating speeds observed in 1992 in each SOC were used in the assessment of that SOC;
- At SOCs where insufficient MTB operating speed information was gathered, MTBs were assumed to operate at 30 mph on the Hellgate Study Reach and 25 mph on the Gold Hill Study reach;
- The downstream drifting speed of MTBs was assumed to 1.5 that of the average FC float speed through the appropriate reach;
    - This in turn assumes that: 1) the water velocity is determined by the average observed FC float speed; and, 2) that the MTB needs to travel faster than the water to maintain positive maneuvering control.

10) FC Operational Practices:

Similar to MTB operations, the fault-tree risk assessment method for BS/C issues demands that specific assumptions be applied to FC operational practices. A basic set of FC operational assumptions were developed to appropriately execute the SOC/scenario assessments. The unifying set of FC operational rules for FC involved in FC/MTB encounter situations were based on four basic modeling assumptions: 1) the FC operators have low boating skills and have little experience operating with MTBs; 2) the FC operators have little experience with the channel and hydraulics of the SOC; 3) FC operator judgement can not be relied upon to recognize potential safety risk situations nor to determine the action that would lead to the least safety risk; and, 4) FC operator skills can not be relied upon to execute FC maneuvers necessary to avoid or lessen safety risks. It is recognized in this BS/C Study that not all FC users can be characterized by this set of assumptions but given the relatively casual nature of most of the study area FC users it is likely that a MTB/FC encounter in a SOC will involve FC users that can not be relied upon to avoid or reduce the safety risk situations. More generous FC operator assumptions would interject behavioral choices that, from a practical perspective, would make safety risk modeling impossible and would provide results that underestimate potential safety risks.

In addition to the above FC operational assumptions several other FC operational practice assumptions were developed for use in the SOC Assessments. These include:

- FC that encounter MTBs in a SOC will proceed through the SOC in accordance with normal user patterns;
- Minimum, average, and maximum FC float speeds observed in the 1992 in each SOC were representational and used in the assessment of that SOC;
- At SOCs where insufficient FC float speeds information was gathered FC float speed observations in other similar channel/hydraulic conditions were used;
- FC float speed information collected both during low and high flow conditions were combined into a single data set and was reasonably appropriate for use in SOC Assessments at both low and high flow conditions (as defined in this BS/C Study);
- The FC user patterns at SOCs observed in 1992 were typical, this includes:
    - FC float route splits,
    - accidental flips, swims, and broaches, etc,
    - special patterns such as lunch stops, swimming stops, and carry/re-runs at SOCs.

Figure 11

LOW PERFORMANCE Pvt-JB

A low performance pvt-JB fishing sled typical of the type used on both study reaches. These craft range from approximately 12-20 ft. long and are powered by single or twin outboard jets. They are particularly prevalent during the fall anadromous fish runs.

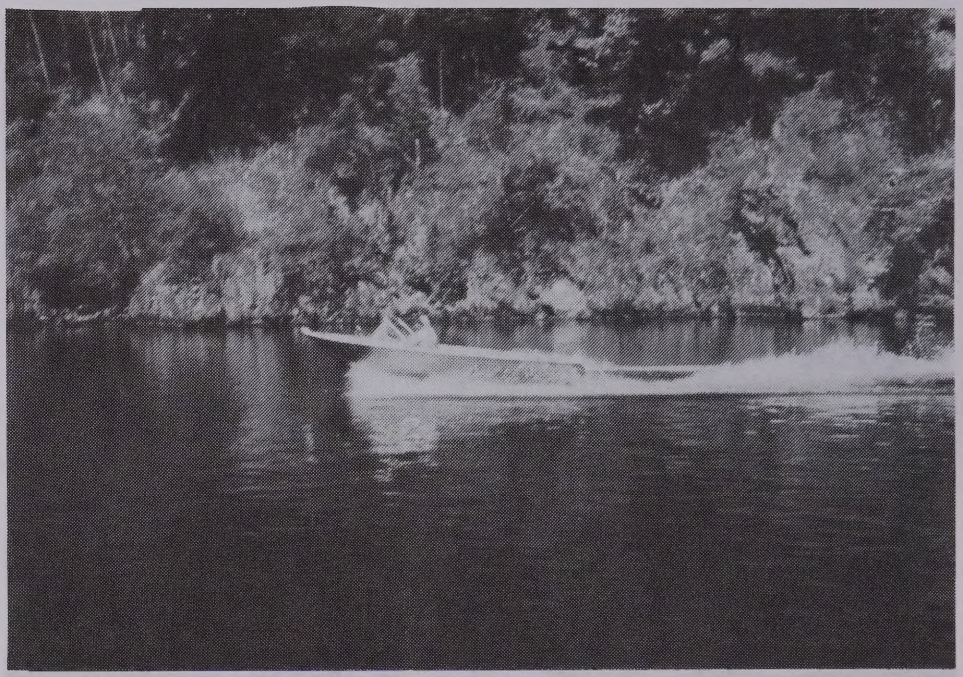


Figure 12

HIGH PERFORMANCE Pvt-JB

A high performance pvt-JB typical of the type used on both study reaches. They are 15-20 ft. long and powered by a single inboard jet. They are used throughout the year for boating recreation.

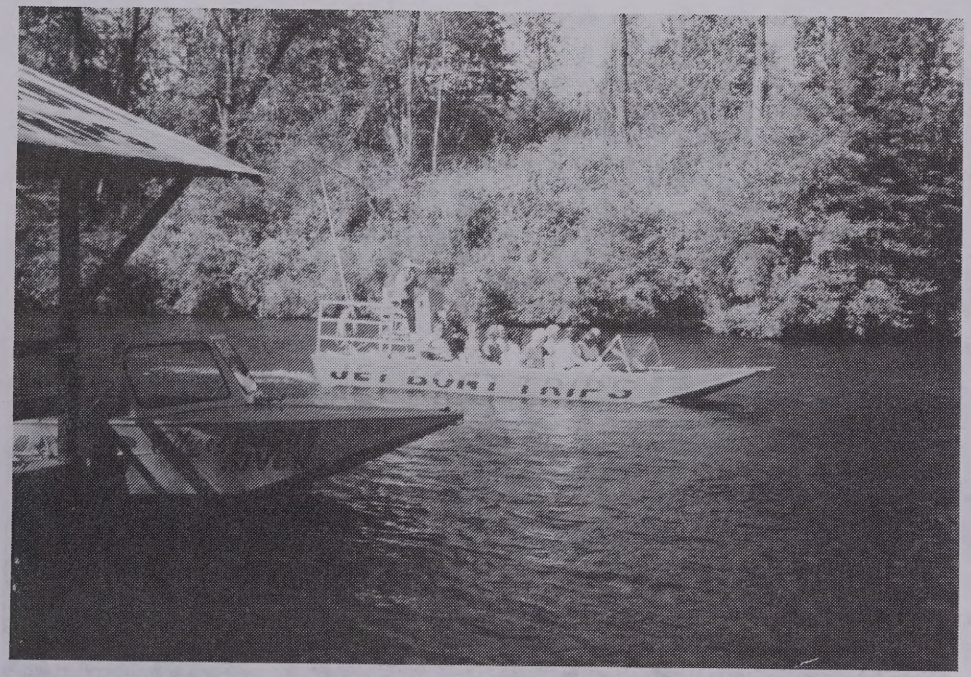


Figure 13

"SMALL" SIZED MTB

The "Miss Woodville" (see Table 1) is an example "Small" sized MTB referred to in this study. These sized MTBs are only in use on the Gold Hill Study Reach. The "City of Rogue River" is in the foreground.

Figure 14

"MEDIUM" SIZED MTB

The "Argo" (see Table 1) is an example "Medium" sized MTB referred to in this study. These sized MTBs are only in use on the Hellgate Study Reach, mostly on Whitewater MTB trip itineraries. This photograph was taken at Mark's Island.

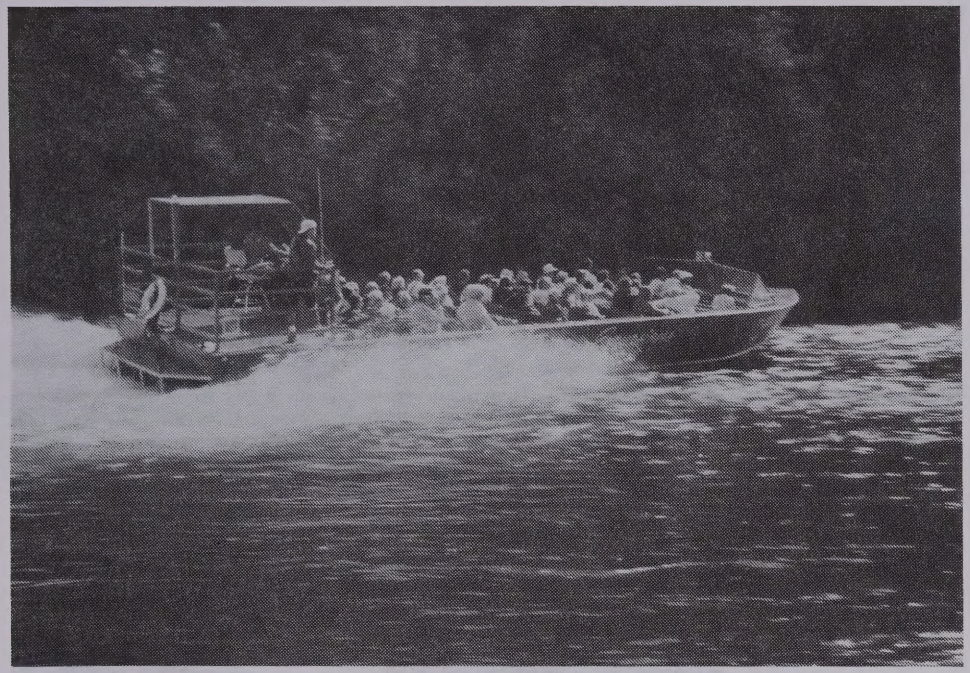


Figure 15

"LARGE" SIZED MTB

The "Ginni Mac" (see Table 1) is an example "Large" sized MTB referred to in this study. These sized MTBs are only in use on the Scenic Section of the Hellgate Study Reach.

Figure 16

"THRILL" TYPE MTB

This is a small, high performance MTB on the Waikato River near Taupo, New Zealand. It is about 14 ft. long, has a total capacity of 12 passengers and crew, and is powered by a single 480 hp inboard jet. These craft are used for short duration, "thrill" outings emphasizing close passages of bank, river-side vegetation, rocks, etc. and high speed turns and spins. MTBs of this size are typical of New Zealand river resources.

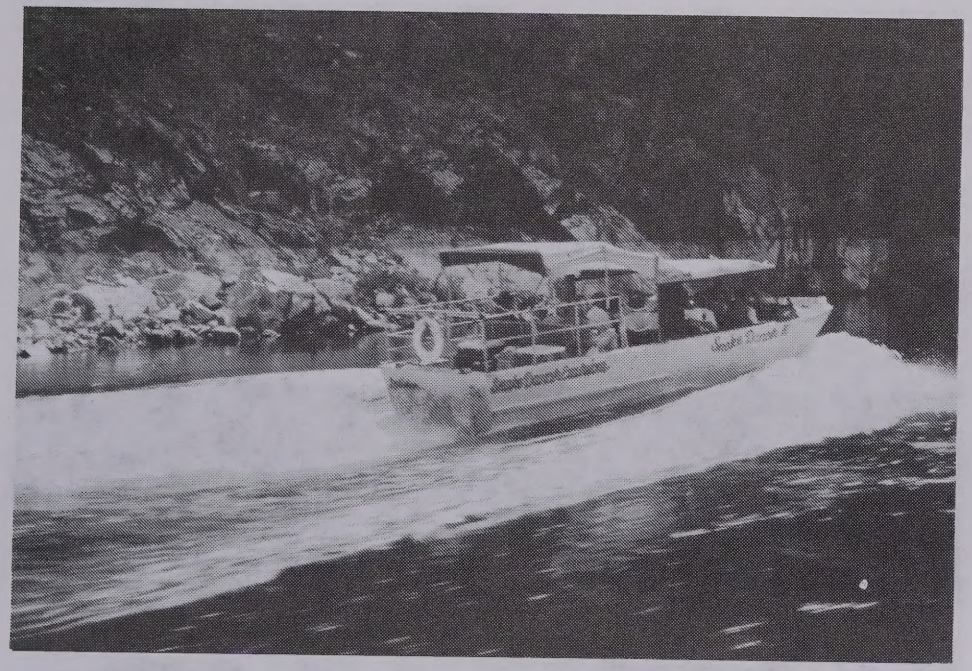


Figure 17

EXAMPLE MTB

This MTB is operating on the Hells Canyon portion of the Snake River, ID-OR. It is about 25-30 ft. long.

Figure 18

EXAMPLE MTB

This MTB is operating on the Colorado River below Moab, UT. It is about 35 ft. long and is powered by a single inboard jet.

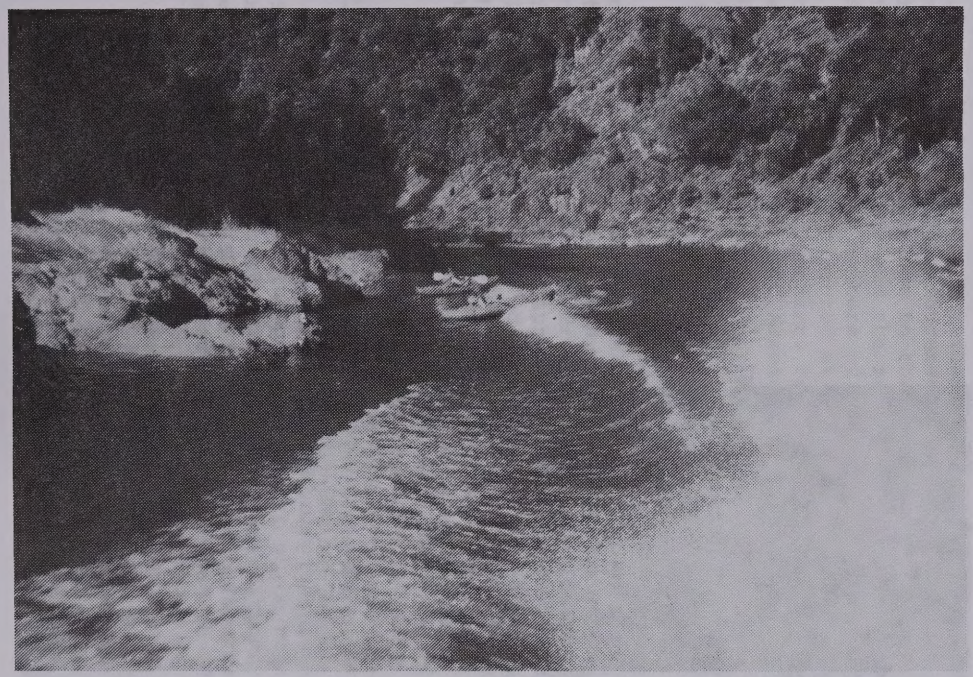


Figure 19

INFLATABLE KAYAKS

Inflatable kayakers in typical MTB wake.

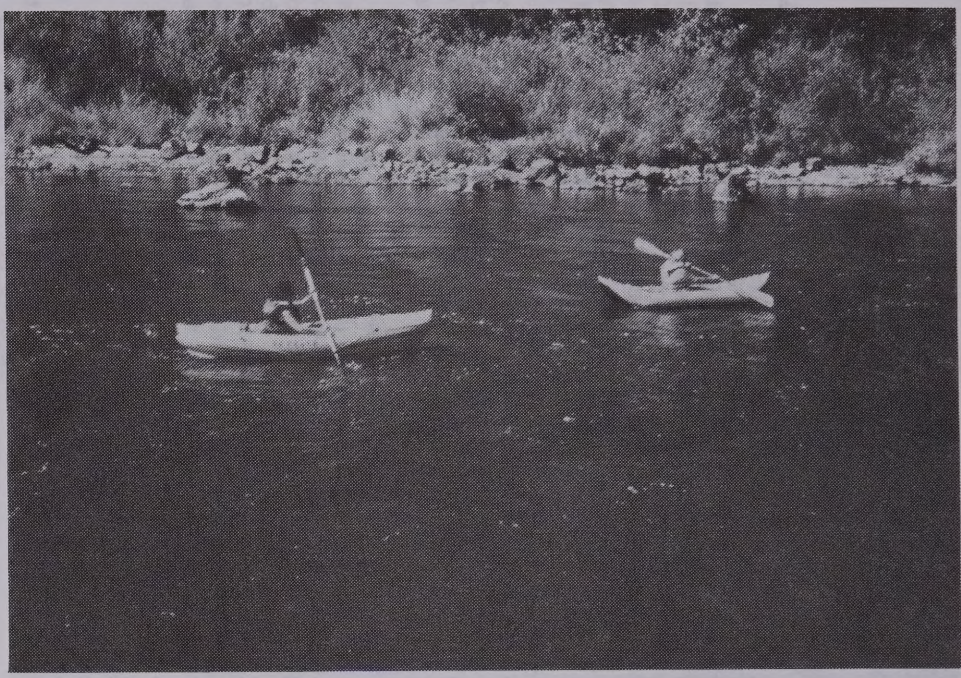


Figure 20

INFLATABLE KAYAKS

Inflatable kayakers typical of a large number of FC users on both study reaches.

Figure 21

DRIFTBOATS

Driftboats in Indian Riffle near Indian Mary Park. When used for river boating recreation, driftboats are assumed to have the use patterns of floatcraft (FC). When used for angling they spend much more time at specific locations and cover much less river in a recreation day. Driftboats are occasionally used during the summer for boating recreation but are the predominant activity types during the fall anadromous fish runs.

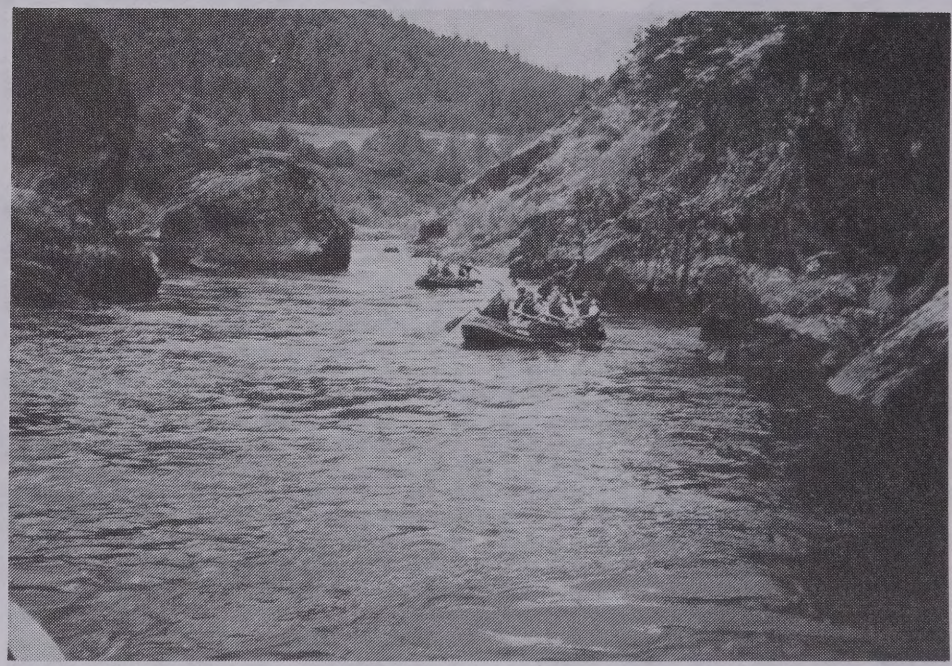


Figure 22

PADDLE RAFTS

Paddle rafts used in the study area vary in size from 8 to 16 ft. long and accommodate from 2 to 10 passengers. Oar rafts are also in use but tend to be larger (10-16 ft. long) and carry fewer passengers (2-6). When the oars are extended oar rafts can have an overall width of up to 20 ft. (See Figures 25, 26).

11) Flow Range and Channel/Hydraulic Conditions:

It was initially recognized by the cosponsoring agencies that BS/C issues vary with streamflow magnitudes and that at lower flows safety risk and conflict problems may be intensified due to reduced navigational clearances and reduced margins of safety. This variable risk induced by streamflow magnitude was corroborated by both JB and FC operator members of the FG. The BS/C Study field work also noted changes in hydraulic conditions and general operating room that resulted in both greater safety risks and reduced margins for safety at lower flows.

While much of the BS/C Study involves determining the relative safety risks associated with both high flow and low flow conditions, the identification of threshold flows that separate the streamflow continuum into discrete flow ranges is more elusive. For SOC Assessment purposes functional definitions for the two flow conditions were developed.

Lower flow conditions were represented by reduced effective channel area, and increased navigational hazards that result in increased MTB operational limitations, reduced MTB operational options, and greater potential safety risks. These conditions occur over an unspecified flow range between, at a minimum, a flow just above a self-imposed MTB navigational limit, and at a maximum, a flow just below that which channel hydraulic conditions shift to those with reduced potential safety risks (high flow range). This definition was based on the premise that with declining streamflows, adequate safety margins for craft encounters will degrade before navigation limits are reached.

Higher flow conditions were represented by relatively open channel conditions with, larger effective channel areas, increased MTB operational options, and decreased potential safety risks. These conditions occur over an unspecified flow range between, at a minimum, a flow just above that which channel hydraulic conditions shift to those with greater potential safety risk (low flow range), and at a maximum, the typical upper limit of flows during the main recreation season.

For the SOC Assessment process each SOC was evaluated for low and high flow channel/hydraulic conditions. The physical characteristics of the SOCs under these flow conditions were determined by field measurements at decidedly low flow and decidedly high flow conditions without reference to the specific flow range that these conditions would apply. These field measurements and the resulting MTB operational limitations were reviewed by the MTB and pvt-JB operator members of the FG. Observations of MTB and FC use characteristics at the SOCs were also conducted at these decidedly low and high flow conditions. These characteristics and use patterns reflected in the example SOC Assessment Plates in Part IV of this chapter. At the SOC Assessment stage, the safety risks of the various SOC/scenarios are addressed only by an unspecified low, more risky flow, and a high, less risky flow; the actual flow magnitude that create the two channel/hydraulic conditions are not addressed.

The streamflow boundary (cfs) of these functionally defined flow conditions can vary based on: 1) methods employed in computing estimates streamflows; 2) focal point for the streamflow computation; 3) study reach section under consideration; and, 4) individual perceptions of the channel/hydraulic boundary conditions that separate low flow (higher potential safety risk) and high flow (lower potential safety risk) conditions. These variables should be considered when applying the results of the SR/C Model and when modeling potential safety risks for an actual MRS with actual daily average streamflow estimates.

12) Channel Conditions:

The SOC Assessments were conducted using the channel characteristics found during the 1992 season. This included the degree to which riparian vegetation was managed in 1992 to improve visibility. The 1992 SOC channel conditions are characterized on the individual SOC/scenario assessment plates in this chapter. Important channel characteristics that were used in assessing the safety risk exposure at the SOCs included the size and location

MTB operational decision locations (also derived from set-down threshold locations). The SOC channel characteristics most important to issues of potential safety risk include: 1) the location of MTB RIPs (controlled by set-down threshold locations and MTB SSDs) and the visual screening which together control the probability that MTBs will enter SOCs when unseen FC are present (PNS); and 2) the presence of usable set-down areas and driftable portions within SOCs both of which improve MTB options available for avoiding safety risk problems (PSRs).

The channel characteristics listed above in part drive the degree to which the various channel sections qualify as SOCs (MTB operational limitation/LOS limitations) and the degree to which SOCs represent potential safety risk. All of these characteristics are sensitive to changing streamflow and sediment budget regimes which can change on both long and short term scales and can result in both local and whole reach channel changes. The channel of the study area, particularly portions of the Hellgate Study Reach, show signs of on-going channel changes that could, in the future, lead to modified SOC Assessment safety risk results. Factors that may lead to long and short termed changing SOC channel characteristics include historic in-channel gravel mining in the vicinity of the Applegate River confluence, the significant coarse sediment transport reduction below Gold Ray and Salvage Rapids dams, and a changed streamflow regime due the operations of both the Lost Creek Dam on the Rogue River and the Applegate Dam on the Applegate River. Channel changes could modify safety risk exposures in some of the SOCs in the near term and on a year-to-year basis.

As a result of these anticipated channel changes the BS/C results based on the SOC Assessments, are technically valid only for the site conditions observed in 1992. From year to year minor changes in important BS/C related channel characteristics could result in different PNS and PSR characteristics and levels of inherent safety risks.

The channel reaches with on-going channel changes most affected by sediment and streamflow regime shifts due to dam operations alone is the entire Gold Hill Study Reach and, on the Hellgate Study Reach, from Grants Pass to and through Middleton's (RM 0-6.5) In these reaches, channel conditions are basically stable because upstream dams have influenced sediment loads for many decades. The deposition of fine sediment in Eiseman's Stillwater could lead to some channel changes in the future but this change is not likely to alter safety risks.

The Hellgate Study Reach through Applegate and past "50-Rocks" (RM 6.5 to 8.7) is affected by a complex response to changed streamflow and sediment regimes on both the Rogue River and Applegate River, and an apparent history of in-channel gravel extraction operations. In this reach on-going channel changes appear to be relatively active. Presently the gravel-mined channel area of Whitehorse is overwidened and is a coarse grained sediment sink. Incoming sediment is deposited in this overwidened area which could result in significant channel changes in both the short and long term. These changes include the reconfiguration of channels and islands at Whitehorse, changes in FC route distribution, changes in MTB route curvature, MTB operational limitations, and changes in visual screening. Because of the sediment sink characteristics at Whitehorse, the channel reach from Whitehorse to "50-Rocks" is one in which sediment scour processes predominate. The channel dynamic regime in this reach is resulting in the removal of transportable coarse sediment and the exposure of bedrock features ("50-Rocks"). The exposure of bedrock results in more complex MTB navigation problems, but because of little channel curvature and the low gradient in this reach, no SOC conditions should result. Over time the sediment scour regime may progress downstream until such time as the Whitehorse sediment sink area begins to fill and coarse sediment starts to pass through that reach.

The reach from the Applegate River confluence downstream through "50-Rocks" and beyond is also subject to major short termed channel changes should a major streamflow/ sediment discharge event occur on the Applegate River. This could cause a large amount of coarse sediment to be deposited in the Rogue River channel under a floodflow hydraulic regime. Subsequent more typical lower flows would rework this sediment until the bed conforms to long termed typical flow hydraulics. The bedforms under these conditions would be significantly different than those of the 1992 season and the resulting short termed and long termed SOC safety risk characteristics would be considerably different.

Figure 23

TWO-BIT RIFFLE

Near vertical aerial photo of Two-Bit Riffle, in the Scenic Section, under low flow channel/hydraulic conditions (about 1050 cfs) (Refer to Plate 19). This riffle, while mainly composed of gravel material, is really controlled by bedrock features. Channel curvature, bedform, and bedform positions are controlled by the bedrock that forms the RL bank and by a bedrock ledge buried in the gravel in the main drop. The thin curvilinear white line extending upstream through the center of the photograph from the bright exposed bar to the vegetated island bank is a line of sand bags along the RL edge of the RR channel placed by the MTB owner/operator to enhance flows in the main drop to improve MTB navigation.

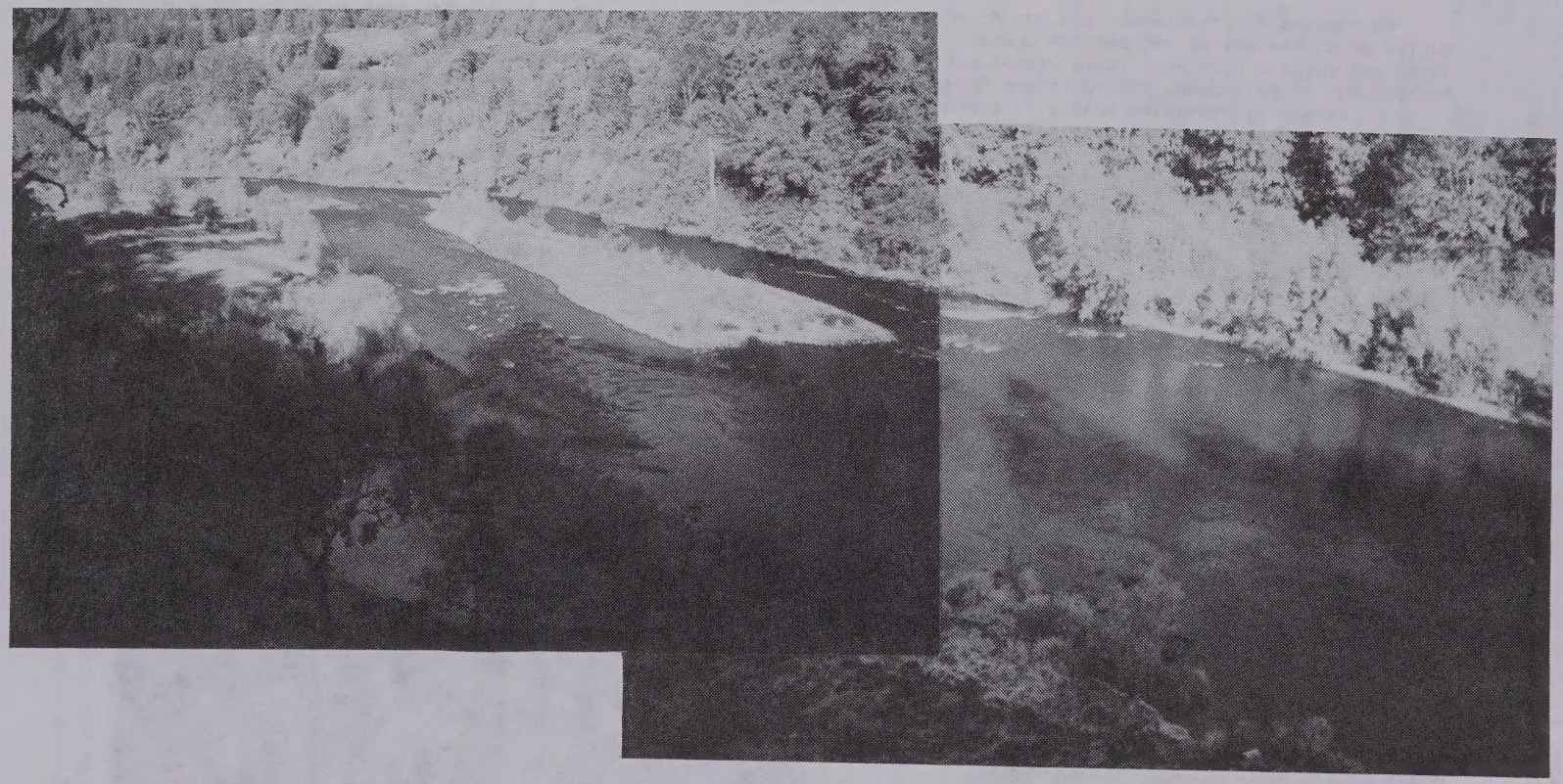


Figure 24

HOG CREEK ISLAND

Downstream view of the Hog Creek Island area in the Scenic Section (See Plate 23). The hydraulics are basically riffle in nature but bedrock controls on the RR bank maintain channel curvature and rapid-like tailwater hydraulics in the tailwater area. The bedrock along the RR bank maintains channel curvature in the lower portion of this area and the channel curvature maintains the multi-channel, multi-island pattern by way of the backwater/cushion hydraulics during floodflows. Changing local sediment flux could alter the size of usable set-down areas in the riffle which could change the safety risk parameters from year to year but the long term basic configuration of this riffle is stable.

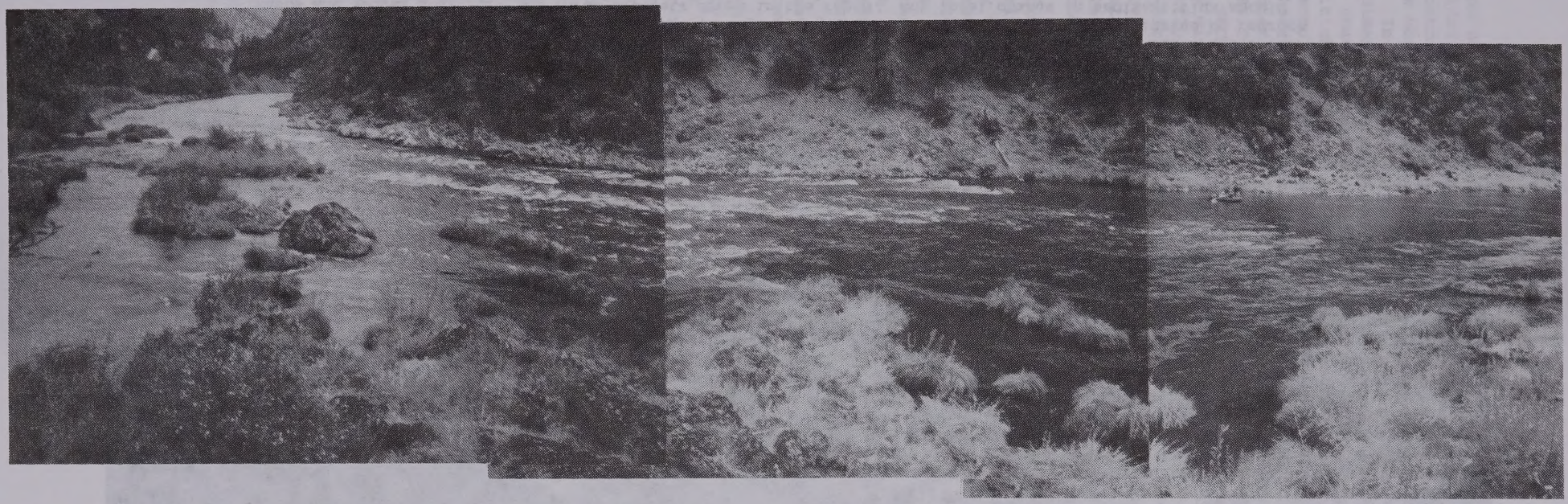


Figure 25

ARGO RIFFLE

A ground photo of Argo Riffle, in the Whitewater Section, under high flow channel/hydraulic conditions (Refer to Plate 63). The oar raft is located in the glide between Points D and E on Plate 63 and would be out of sight from the upstream running MTB located in the vicinity of the RIP (See Figure 36). This rapid is controlled by bedrock banks and a bedrock ledge on RL that strands cobble materials. Because of the bedrock controls this rapid has stable features; little long term change in safety risk parameters are expected.

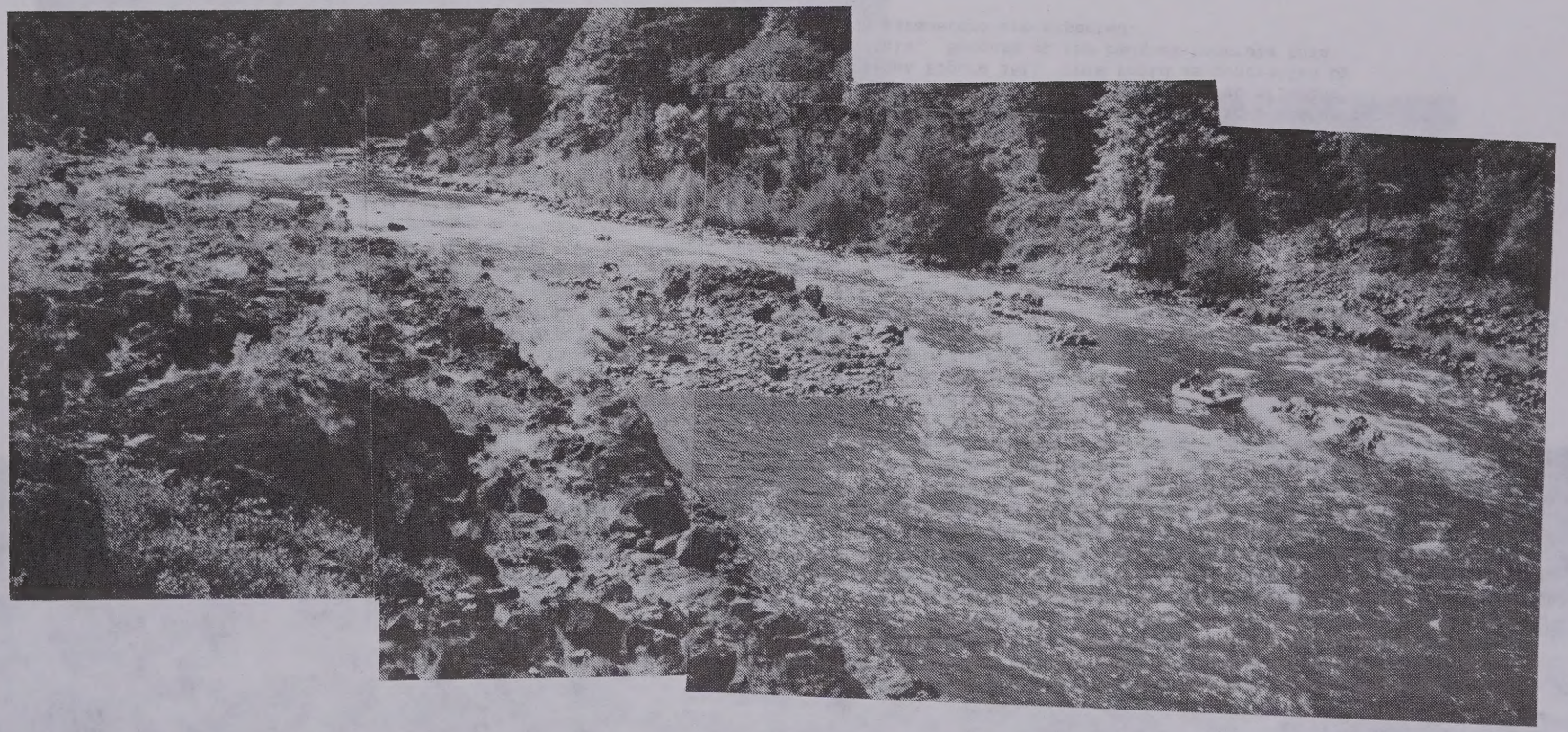


Figure 26

WOOLDRIDGE RIFFLE

An upstream view of Wooldridge Riffle, in the Whitewater Section, under low flow channel/hydraulic conditions (Refer to Plate 64). This is a bedrock controlled rapid. Both banks are bedrock dominated with a scour terrace on RR with a veneer of large cobble deposited during major floodflow events. The bed is dominated by bedrock knobs and ledges that form the three discrete drops in the rapid. Any local change in sediment flux should translate through this rapid without any substantial change in MTB set-down area characteristics. The oar raft is in one of the three bedrock controlled exit routes.

From Bedrock Riffle through to the Hog Creek Ramp (RM 8.7 to 18.8) the channel has a broad pool/riffle character created by fluvial processes within the context of overall bedrock control of the riverine system. Channel curvature results from fluvial dynamics within the narrow confines of bedrock valley margins and occasionally bedrock bank and bed controls. In this reach channel characteristics important to BS/C concerns are sensitive to the sediment and streamflow regimes resulting from upstream influences. For the most part this reach is in a state of dynamic equilibrium; a condition in which channel bed and bank conditions are expected to change over time at specific locations but the general fluvial geomorphic patterns of the reach should remain reasonably consistent. Therefore at specific locations slow paced channel changes are possible that could lead to changes in SOC characteristics. Over time the changing channel characteristics at SOCs will lead to changing BS/C characteristics and concerns. At some SOCs the channel characteristics that make them SOCs may eventually disappear while in other areas new SOCs may develop. In some cases only minor changes in the size of set-down areas or driftable reaches could lead to significantly different BS/C results. This is particularly true of Brushy Chutes, Highway Hole, Two-Bit Riffle, and Hog Creek Island. While site specific channel characteristics will change with time, as will the specific BS/C details of the SOCs, the reach is fundamentally stable and basic channel configuration should remain the same. In the foreseeable future, when the BS/C concerns of this reach are taken together, safety risk exposure concerns should remain generally the same.

A notable exception to the overall stable, slow changing character of this reach is the channel section that includes Brushy Chutes and Highway Hole (RM 13.2-14.6). Presently the Brushy Chutes area has a medial bar configuration with relatively high rates of channel location and curvature change. In most but not all situations similar to those observed at Brushy Chutes, the presence of medial bar channel patterns are indicative of unstable conditions. Understanding the root cause of the medial bar configuration is beyond the scope of the BS/C Study but may be related to a slug of coarse sediment slowly progressing downstream. Highway Hole has also changed significantly in recent years potentially as a partial result of channel length and sediment flux changes at Brushy Chutes. The BS/C characteristics of Brushy Chutes and Highway Hole are expected to change on a year to year basis and, over the long term, be very much different than they are at present. The safety risk parameters of the SOCs can be expected to change dramatically with channel curvature and set-down area changes.

From Hog Creek Ramp through to Grave Creek (RM 18.8 to 33.3) the channel is more confined by bedrock valley margins and bedrock channel controls. These bedrock features cause most of the drops in this reach to take on the characteristics of "rapids", as opposed to riffles. They do not have the consistent and classic riffle bedforms nor the channel pattern that result exclusively from the hydraulic interaction of streamflow and sediment regimes. Therefore although the SOCs in this reach are locally known as "riffles", the majority of the drops are really low gradient rapids with hydraulics controlled directly and indirectly by bedrock features.

In this reach the channel configuration is basically stable. Only minor short termed changes in channel characteristics should occur and because of the concentrated hydraulic patterns imposed by bedrock controls, little changes in set-down area characteristics are likely. On the other hand minor changes in MTB operational characteristics and operational limitations could lead to significant changes in BS/C concerns in those SOCs. The most significant changes in BS/C characteristics that may occur in this reach are probably related to the occurrence of very rare sediment pulses from small tributaries that could cause short termed changes in local SOCs.

The SOCs in the Hellgate Study Reach most subject to changing channel characteristics and changing safety risk estimates include in downstream order: 1) the mouth of the Applegate, due to coarse sediment deposition and channel curvature changes; 2) Whitehorse, due to changing channel and island patterns and changing FC route selection and MTB set-down areas; 3) Brushy Chutes, due to basic channel shifting, changing curvature and MTB set-down areas; 4) Two-Bit, due to changing MTB set-down areas; and, 5) Hog Creek Islands, due to changing set-down areas. Highway Hole, presently not a SOC within the definitions in this BS/C Study, is a location where basic channel pattern shifts are on-going and it is reasonable to expect that SOC conditions could develop in the future.

On the Gold Hill Study Reach observed channel conditions appear to be reasonable stable presumably due to the close upstream proximity of Gold Ray Dam which has been storing coarse sediment for a long period. While some SOCs in the Study Reach may change somewhat over time, the rates of change are expected to be slow and not modify safety risk exposures greatly.

C: Fault-Tree Risk Assessment Approach

The field review of activity patterns in SOCs and the observed types of potential safety risks indicated that safety risk potential is related to the results of a sequential series of safety risk conditions and operational choices made by MTB operators in response to conditions within SOCs. The circumstances of each safety risk condition and the operational choices made by MTB operators lead to distinct MTB operational run scenarios through the SOCs. Each operational scenario has a range of likelihoods based on use patterns and the physical characteristics of SOCs, and each operational scenario may result in different safety risk exposures. The MTB operational scenarios and variable safety risk concerns at the SOCs can be addressed by a fault-tree risk assessment approach.

A fault-tree risk assessment approach is a useful tool when a risk environment (SOCs) has more than one safety risk component and when there are a sequence of interdependent safety risk elements and/or safety risk decisions that drive outcomes. These interdependent cascading safety risk elements and decision points result in a branching pattern of alternative risk scenarios, thus the term fault-tree. The relative frequencies of various operational paths of the fault-tree and the associated safety risks of those paths can be determined based on the relative probabilities for specific conditions existing at each safety risk element and at each decision point, and the rules that govern the operational response to sets of conditions.

At the SOCs of the study area the circumstances associated with some of the MTB operator decision points are different between downstream and upstream SOC runs. Therefore the structure of the fault-trees for the two operational directions are slightly different.

1) Downstream MTB Operational Fault-tree:

When the MTB arrives at a SOC the decision whether or not to proceed is based on the MTB operator's view into the SOC and whether or not FC are observed. The model rules dictate that the MTB proceeds without stopping if no FC are observed. The absence of observed FC can result from either a condition where there are no FC in the SOC at all or there are FC in the SOC but all are at locations that are not observable from the RIP. The probability that FC occupy or do not occupy the SOC at the moment of MTB arrival is based on the estimated number of FC expected in the 15-minute float segment within which the SOC is located (from the FC Use Distribution Model) and the size of the SOC relative to the length of the 15-minute float segment. In the hypothetical downstream example in Figure 27A, at the moment of MTB arrival there is a .900 probability that the SOC is unoccupied and a .100 probability that there is at least 1 FC in the SOC. In this hypothetical example there is .600 probability that all the occupying FC are unseen from the RIP and a .400 probability of at least 1 FC being seen based on parameters such as the size of the seen and unseen portions of the SOC, the number of FC that are expected to be in the SOC at the moment of MTB arrival, and the assumed overlap distribution of FC in the SOC. As a result, when a MTB arrives there is a .060 probability that there are FC in the SOC and they are not seen, a .040 probability that there are FC in the SOC and at least 1 is seen, and a .900 probability that there is no FC in the SOC. Therefore there is a .960 probability that the MTB operator will see no FC and will run directly into the SOC. Conversely there is a .040 probability that a FC will be seen and the MTB operator will stop at the RIP for the FC to float though the SOC.

The probability that a potential accident situation occurs for this hypothetical example SOC is associated with either one of two scenarios: 1) the risks associated with running directly into the SOC when the SOC is occupied (a .060 probability); and 2) the risks associated with waiting at the RIP and running after all observed FC have floated out of the SOC (a .040 probability). An MTB running the SOC without any FC present incurs no safety risks.

The risks associated with running directly through the SOC without stopping result from the PSRs of: 1) overtaking FC before the FC reach the end of the SOC; 2) time-dependent pop-outs at locations within the SOC; and 3) time-independent pop-outs within the SOC. In this hypothetical example these probabilities are shown as .165, .030, and .010 respectively; a total PSR of .205. The resulting PMO of this MTB operational scenario is .0123 or a 1.2% chance for a safety risk situation each time a MTB trip arrives at this SOC under the hypothetical FC use level.

Until FC use levels get so high as to preclude any adequate gap during a 15-minute period, eventually during a 15-minute period an adequate gap will occur that allows the MTB to proceed. Thus until the point of physical saturation, there is a 1.0 probability that the MTB run can be re-initiated at some point in a 15-minute period.

The risks associated with the scenario of the MTB running after stopping at the RIP results only from the safety risk probabilities of the time-independent pop-outs because by definition, time-independent pop-outs can occur at any time and are not related to when a FC enters the SOC. This results from the assumption that the MTB operator waits at the RIP long enough for the observed FC to reach the end of the SOC whether or not the FC floats directly through the SOC or is delayed in a time-dependent pop-out situation. While waiting at the RIP the MTB operator's knowledge field is assumed to extend downstream past the seen portion of the SOC as the MTB wait progresses. In addition, in-floating FC can be monitored. Should any FC enter the SOC while the MTB is waiting at the RIP it is assumed that the MTB operator waits long enough for the last FC observed in the seen portion of the SOC to float to the end of the SOC. The PSR for time-independent pop-outs is .010 in this hypothetical example which results in a PMO for this MTB operational scenario of .0004 or a 0.04% chance for a potential safety risk situation each time a MTB trip arrives at this SOC under the hypothetical FC use level.

The total safety risk potential for a downstream operating MTB arriving at the SOC is the sum of the PMOs of the various MTB operational components. For the hypothetical SOC and level of FC use example this is (no FC in the SOC, .0; running directly into the SOC, .0123; and stopping to wait, .0004) a total PMO of .0127.

2) Upstream MTB Operational Fault-tree:

In the hypothetical example upstream fault-tree on Figure 27B the FC use levels and SOC length parameters are assumed to be such that the probability of no FC being in the SOC upon MTB arrival is .900 and the probability that there is at least 1 FC in the SOC is .100. Based on the physical characteristics of the hypothetical example SOC the probabilities that all the FC are in the unseen portion of the SOC is .600 and the probability that at least 1 FC is in the seen portion is .400. As a result, when a MTB arrives there is a .060 probability that all of the FC in the SOC are not seen, a .040 probability that at least 1 of the FC in the SOC is seen, and a .900 probability that there is no FC in the SOC. Therefore there is a .960 probability that the MTB operator will see no FC and will run directly into the SOC without stopping. Conversely there is a .040 probability that a FC will be seen and the MTB operator will stop at the RIP for the FC to float though the SOC.

The probability that a potential accident situation occurs in this hypothetical example SOC is associated with either one of two scenarios: 1) the risks associated with running directly into the SOC when the SOC is occupied (a .060 probability); and 2) the risks associated with waiting at the RIP and running after the observed FC has floated out of the SOC (a .040 probability). A MTB running the SOC without any FC present incurs no safety risks.

The risks associated with running directly through the SOC without stopping result from the PSRs of all the various safety risk elements identified. These could include direct overrunning, float-bys in set-down areas, and float-ins at the top of the SOCs. In this example the composite PSR is shown as .205. The resulting PMO of this MTB operational scenario is .0123 or a 1.2% chance for a potential safety risk situation each time a MTB trip arrives at this SOC under the prescribed FC use level.

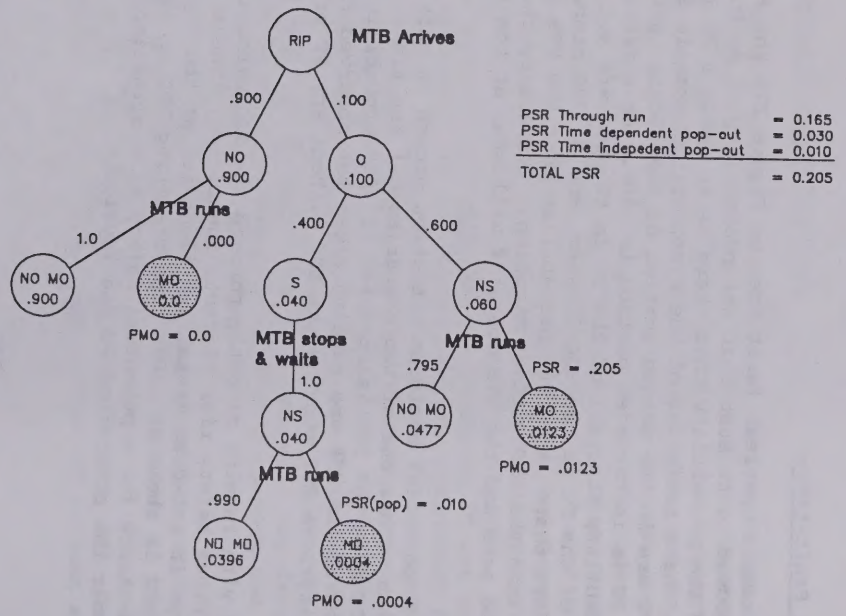
Figure 27

Example SOC Fault-Trees

Rogue River BS/C Study

(Hypothetical Safety Risk Parameters)

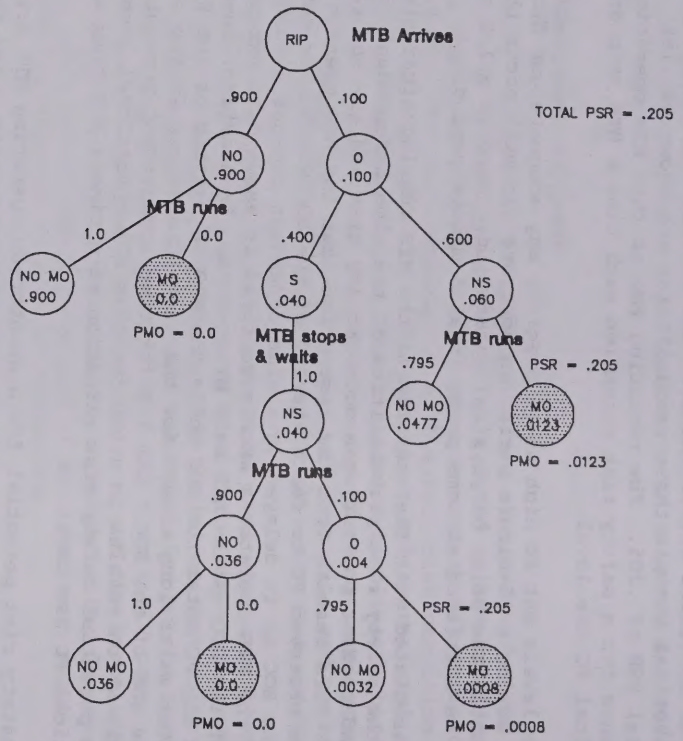
A. Downstream Operations



PSR Through run = 0.165
PSR Time dependent pop-out = 0.030
PSR Time independent pop-out = 0.010
TOTAL PSR = 0.205

Total PMO = 0 + .0004 + .0123 = 0.127

B. Upstream Operations



Total PMO = 0 + 0 + .0008 + .0123 = .0131

Legend

RIP	– MTB arrives at Run Initiation Point
NO	– SOC is not occupied by any FC
O	– SOC is occupied by at least one FC
S	– At least one FC is seen by MTB operator
NS	– No FC are seen by MTB operator
NO MO	– Mutual Occupation does not occur
MO	– Mutual Occupation does occur
PMO	– Probability of Mutual Occupation
PSR	– Probability of Safety Risk

If the MTB operator observes FC in the SOC on arrival the MTB is stopped. Once a MTB is stopped at the bottom of a SOC to wait for FC to float out of the seen portion, the MTB operator waits until the view field is clear of FC before re-initiating the run. Unlike downstream operations, the MTB operator's knowledge field does not expand with increasing wait duration. Therefore, while waiting at the RIP, FC activities above the LOS threshold are unknown to the MTB operator and new FC could be floating into the SOC during the wait. Also it is assumed that during the MTB wait as the FC observed in the SOC float past the bottom of the SOC, new FC are entering the top of the 15-minute float segment that contains the specific SOC. The FC floating into the top of the 15-minute float segment are assumed to replace those FC that are observed to float out of the SOC so that the probability that the SOC is occupied remains unchanged during the MTB wait period. Once the MTB operator observes no FC in the seen portion of the SOC the MTB run is re-initiated. Until physical saturation is reached there is a 1.0 probability that the MTB run can eventually be re-initiated some time during a 15-minute period.

At the moment that a MTB run is re-initiated, by the above assumed rules, the estimated number of FC expected in the 15-minute float segment is the same as the moment when the MTB first arrived. In addition, the same probabilities for the SOC being occupied (.100) or unoccupied (.900) are in effect. Because the run re-initiation scenario is triggered by the seen portion of the SOC being unoccupied by FC, all the FC likely to occupy the SOC would be in the unseen portion of the SOC. Therefore the probability of a MTB arriving at the SOC, stopping to wait for FC and, upon re-initiating the run, not encountering FC in the SOC is .036. The probability of a MTB arriving at the SOC, stopping to wait for FC and, upon re-initiating the run, encountering FC in the SOC is .004.

The PSR associated with upstream MTB runs after stopping to wait at the bottom of the SOC is the same as for a MTB run should it have been initiated directly upon arrival; in this case .205. The resulting PMO of this MTB operational scenario is .0008 or a 0.08% chance for a potential safety risk situation each time a MTB trip arrives at this SOC under the prescribed FC use level.

The total safety risk potential for a upstream operating MTB arriving at SOCs is the sum of the PMOs of the various MTB operational scenarios. For the hypothetical SOC and level of FC use example the safety risk potential is (no FC in the SOC, .0; running directly into the SOC, .0123; and stopping to wait, .0008) a total PMO of .0131.

PART II: HELLGATE STUDY REACH

Part II presents the SOC Assessment methods developed for the Rogue River BS/C Study. The SOC Assessments determine the probabilities for various safety risk and conflict parameters that are present for each SOC/scenario that result from the various physical channel/hydraulic characteristics of the SOCs, the MTB craft, use, and performance characteristics, and the patterns of FC uses at the SOCs. The SOC Assessment methods developed are then applied to the Hellgate Study Reach SOCs.

D: Single-FC SOC Assessment

The primary products of the Single-FC SOC Assessment are the Probability of Safety Risk (PSR), the Probability of Not being Seen (PNS), and the Probability of a Mutual Occupation incident (PMO) at each SOC/scenario. The PNS is a measure of the likelihood that, if a FC is in the SOC, that the FC is unseen at the time of MTB SOC run initiation. The PSR is a measure of the likelihood that, if a FC is in the unseen portion of an SOC at the time of MTB run initiation, a MTB operator can not avoid a MTB/FC encounter that involves less than safety craft separation distance because of the physical characteristics of the SOC, operational characteristics of the MTBs, and FC user patterns. When unavoidable MTB/FC encounters occur that have less than the defined safety craft separation distances due to circumstances beyond the control of MTB operators, it was defined as an inadvertent Mutual Occupation incident (MO). In this BS/C Study, circumstances under which inadvertent MOs can occur are considered potential safety hazard situations. The PMO is a measure of the likelihood of a MO incident if a MTB initiates a SOC run when the SOC is occupied by FC but are unseen from the RIP.

Each of these three safety risk parameters for single-FC situations are developed in this section for each of the SOC/scenarios. The PNSs and PSRs for the SOC/scenarios were developed using the MTB operational fault-tree approach as presented above. The specific analytic steps and the safety risk descriptive narratives for the PSRs and PNSs for each SOC/scenario are presented in the Plate section of this chapter. The specific SOC/scenario safety risk parameters (PNS, PSR, and PMO) are presented in Table 2.

The following paragraphs present an introductory level discussion on the sequential steps of Single-FC SOC Assessment procedures. In addition please refer to Appendix F for a complete description of the analytical methods employed to determine PSRs and PNSs.

1) Probability of Safety Risk (PSR):

The PSR is the probability that, if a FC is located in an unseen portion of a SOC, a MTB and a FC will inadvertently encounter each other in an area where MTB operational options and channel conditions result in a potential safety risk situation. The PSR is calculated slightly differently for downstream and upstream MTB operations.

a) Downstream MTB Operations; The general risks associated with downstream MTB operations include both "through-run" risks and "pop-out" risks. In downstream JB operations, the "through-run" risks are a function of whether the JB overtakes the FC before the FC can float to the end of the SOC (defined by the ST).

In some SOCs there are "pop-out" situations usually located at or near the bottom of the SOC. Some of these pop-out risks are time-dependent and others are not. Time-dependent pop-outs occur at locations where there are unusually long FC transit times due to unusual circumstances and the probability of the pop-out occurring (the FC reaching the point of possible safety risk) is related to the time at which the FC entered the SOC or the pop-out situation. The probability of a time-dependent pop-out decreases with increasing JB wait times at the top of the SOC. These are characteristically associated with FC navigational problems such as flips, broaches on rocks, and becoming entrained in eddies. Time-independent pop-outs occur in situations where the probability of FC being located at the point of potential safety risk is the same at all times regardless of when the FC entered the SOC. These are associated with situations in which FC users purposefully stop within SOCs for lunch or other recreational pursuits and can re-enter portions of the SOC at any time. The probability of these pop-outs does not degrade with JB wait time.

For downstream operating MTBs the general sequence of determining the PSR for a SOC is as follows:

i) The last location a MTB can come to a safe and complete stop before being committed to the SOC is determined. This location is established by first locating the last set-down area in which a MTB can be fully stopped which is wide enough and hydraulically calm enough to allow FC to float past the stopped MTB without incurring a MO, and second, locating the downstream set-down threshold of that set-down area.

ii) The Run Initiation Point (RIP) is set upstream of the last stopping location based upon the SSD. The RIP is the last point at which a MTB operator can observe FC in the SOC ahead and react in time to safely stop the craft before being committed to running the SOC. RIPs are set to accommodate the PSDs of the craft, a reaction time (set at 45' or 1 sec at 30 mph), and the position of the operator (assumed to be the rear of the MTB).

On the Hellgate Study Reach the typical RIP is located 195 ft. above the last stopping location in narrow areas and 165 ft. in wide areas (See Figure 9). On the Gold Hill Study Reach typical RIPs are 165 ft. and 138 ft. above the last stopping point respectively (See Figure 10). Intermediate RIPs may be established where due to operational options and increasing visibility in

the SOC, a MTB operator may choose to set-down to drift or possibly stop to accommodate MTB/FC encounters.

iii) The approach visibility of the MTB is assessed to determine if the field of view into the SOC from the RIP is the most important for use by the MTB operator in determining that the SOC is clear of FC. Lines Of Sight (LOS) from an initial approach position (a location furthest upstream from which the MTB operator has a continuous field of view to the SOC) and the MTB run time from that position to the RIP are compared to the float times of slow FC from the initial LOS threshold to the LOS threshold from the RIP. This determines which MTB view position provides the MTB operator with the largest knowledge field. Typically, MTBs approach SOCs faster than FC can float out of sight and the LOS with the most up-to-date information for a MTB is the LOS at the RIP. If approach views provide additional visual information and are the critical LOSs, adjustments to FC starting locations in a SOC are made to appropriately reduce the level of risk.

iv) The Safety Threshold (ST) is the point at the end of the SOC that accommodates a stopping MTB and provides adequate craft separation between the MTB and FC. For downstream operations the assumed SSD separation distance is 1 MTB boat length as measured from the point a complete stop is achieved. The ST location is set by the PSDs and SSDs from the set-down threshold in the first SOC set-down area which is wide enough to allow FC to float past a stopped MTB without creating a MO situation. There may be more than one ST in particular SOCs, the last ST defines the end of the SOC. On the Hellgate Study Reach this is typically 165 ft. or 60 ft. below the set-down threshold depending upon whether the MTB reaches the set-down threshold at on-plane speeds or at drifting speeds respectively. On the Gold Hill Study Reach typical STs are 138 ft. and 50 ft. below the set-down threshold respectively (See Figures 9 and 10). For SOCs with MTB options for both on-plane and off-plane operations there may be two ST locations.

v) The PSR is calculated for situations when a FC occupies a shadow zone of the SOC when the MTB run is initiated. The shadow zone is that area of the SOC not observable from the MTB RIP due to LOS limitations. The PSR may be determined using a number of different analytic methods. The methods employed are designed for the application of the fault-tree risk assessment method and for selecting MTB operator's operational decisions within the SOC. To develop the basic PSR and the PSRs of the various potential risk elements in the SOC/scenario, the fault-tree path associated with the direct SOC run was assessed (See Figure 27). The following rules were used to govern assumed MTB operations:

(1) If a MTB run is initiated at a RIP, the MTB will operate on-plane in the SOC until a FC is observed.

(2) If, after run initiation, a FC is observed, and the option to bring the MTB off-plane within the SOC is available, the MTB operator will stop or stop to drift as soon as possible. The channel characteristics necessary to either stop or stop to drift include the presence of a set-down area that is long enough as specified by PSDs of the craft and the SSDs as presented in Figures 9 and 10.

(3) If a MTB is brought to a complete stop within a SOC to accommodate FC, the MTB operator will use the best visual information available (knowledge field) in determining when to proceed and complete the SOC run.

(4) If a FC is observed during a MTB run, and there is no option to set-down to stop nor set-down to drift within the SOC, the MTB will be operated on-plane until the set-down at the end of the SOC is reached.

This requirement may entail the MTB to pass FC within the SOC even though in some on-river situations the MTB operator may attempt to set-down to stop or to drift or may even ground the craft to avoid a direct encounter. In either case a potential hazardous situation is assumed to occur: i) a MTB passing FC on-plane within a SOC; or ii) a MTB attempting to set-down to stop or drift where navigational/ operational parameters indicate it would be potentially unsafe to do so.

The probability that the MTB will overtake FC before the FC reaches the ST is calculated using the above fault-tree risk assessment procedures. This assessment is based on average observed on-plane MTB operational speeds and assumed off-plane drifting speeds, and observed range of FC float speeds through different portion of the SOCs. The safety risk to FC in different portions of the shadow zone may be analyzed separately and then weighted based upon the proportion of the shadow zone that they represent.

b) Upstream MTB Operations; The general risks associated with upstream MTB operations include "through-run" risks, "float-in" risks, and "pop-out" risks. In upstream MTB operations, the "through-run" risks occur when the MTB passes (either on or off-plane) a FC that was located between the LOS threshold and the ST on normal FC routes when the MTB run was initiated. Any FC in a "through-run" risk area will incur a MO unless it can float onto another distinctly separate float route before the MTB reaches the FC.

"Float-in" risks are a function of the probability that FC will float to the ST from upstream positions before the MTB reaches a complete stop just below the ST. FC that incur these types of risks start out upstream of the ST at the time of MTB initiation.

Similar to downstream MTB operations, during upstream operations in some SOCs there are "pop-outs" safety risks that are unusual situations in which unseen FC can enter the MTB route suddenly and unexpectedly at short range, often from unusual FC routes. Some of these pop-out risks are time-dependent and others are not. Time-dependent pop-outs occur at locations where the probability of the pop-out occurring (the FC reaching the point of possible safety risk) is related to the elapsed time since the initiation of a MTB wait. A requirement of upstream operating time-dependent pop-out situations is that the MTB operator must be able to stop the MTB (in a set-down area that does not lead to a MO when FC float by) below the point of potential pop-out risk and be able to see the upstream entrance to the pop-out situation. This allows the MTB operator to monitor FC entering the pop-out situation. The probability of a time-dependent pop-out decreases with increasing JB wait times when the entrance of the pop-out situation is under continuous observation. Therefore these pop-out situations are associated with SOC/scenarios where, from the RIP, there is a visual window that allows MTB operators to monitor FC as they enter the top of the unseen segment of the SOC above the stopped MTB.

Time-independent pop-outs occur in situations where the probability of FC being located at the point of potential safety risk is the same at all times regardless of how long a MTB may be stopped at wait. These situations occur when either; 1) the operator of stopped and waiting MTB can not see the entrance of the pop-out situations and therefore can not determine when FC enter the pop-out situations, or, 2) when the entrance to the pop-out situation is observable but FC can enter the channel along the MTB route in unseen portions of the SOC (lunch stop re-launches, unexpected launches etc.). The probability of these time-independent pop-outs does not degrade with increasing JB wait time. Examples of the first situation include all the SOCs in which no visibility window exist and MTB operators can not see above of LOS threshold. This includes most of the SOC LOS threshold situations. An example of the second situation is at Upper Galice in which from the set-down in the main eddy a MTB operator can see above Carpenter's Island and observe FC as they enter the RL channel and pass out of sight behind the island but, since there are FC lunch stops on the blind side of the island, the probability that FC have reentered the RL channel after a stop on the island does not degrade with

MTB wait duration. Another is at Sentinel Rock in Hellgate Riffle (Figures 33-35) where the area far above the rock is visible from the RIP but the FC route to the face of the rock and the face of the rock itself are not visible from the RIP. In this case the MTB operator can see above the unseen area from the RIP and under low conditions the MTB would have to wait at the RIP for up to 10 minutes or more to assure that no FC in the unseen area will pop-out at the edge of the rock when the MTB passes.

The general sequence of determining the PSR for a SOC with upstream operating MTBs is similar to the sequence for downstream operations and is as follows:

i) The last location a MTB can be come to a safe and complete stop before being committed to the SOC is determined in the same manner as with downstream operations.

ii) The RIP is determined in the same manner as with downstream operations except for upstream operations the typical initial RIP is: 1) located 165 ft. downstream of the last stopping location on the Hellgate Study Reach; and 2) located 138 ft. downstream of the last stopping location on the Gold Hill Study Reach.

iii) The approach visibility of the MTB and the critical view positions are determined in the same manner as with downstream operations. For most upstream SOCs the LOS from the RIPs extend further upstream than do the initial approach LOS. Therefore the RIP is nearly always the critical LOS position during upstream operations and offered the largest MTB operator knowledge field.

iv) The ST is the last location in a SOC at which MTB/FC encounters can be defined as inducing a MO. The ST location is set by 1) determining the last set-down area of the SOC, one in which channel widths and hydraulic turbulence are such that MTB/FC encounters would not be a MO and above which MTB/FC encounters would not be a MO situation, 2) identifying the set-down threshold of that set-down area, and 3) using the upstream MTB SSDs which includes a 1.5 boat length for safe craft separation. On the Hellgate Study Reach the ST is typically 150 ft. upstream of a set-down threshold and on the Gold Hill Study Reach the ST is typically 125 ft. upstream of the set-down threshold.

v) The PSR is determined in the same manner as with downstream operations using similar rules to govern assumed MTB operations:

(1) If a MTB run is initiated at a RIP, the MTB will operate on-plane in the SOC until a FC is observed.

(2) If, after run initiation, a FC is observed, and the option to stop within the SOC is available, the MTB operator will stop as soon as possible. The channel characteristics necessary to stop include the presence of a set-down area that is long enough as specified by PSDs of the craft and SSDs as presented in Figures 9 and 10.

(3) If a MTB is brought to a complete stop within a SOC to accommodate FC, the MTB operator will use the best visual information available (view field) in determining when to proceed and complete the SOC run.

(4) If a FC is observed during a MTB run and there is no option to set-down to stop within the SOC, then the MTB will operate on-plane until the stopping location at the end of the SOC.

This requirement may entail the MTB passing FC within the SOC even though in some on-river situations the MTB operator may attempt to set-down to stop or may even ground the craft to avoid a direct encounter. A potential hazardous situation (MO) is assumed to occur when either: i) an on-plane MTB passes FC within a SOC; or ii) a MTB attempts to set-down to stop where navigational/operational parameters indicate it would be potentially unsafe to do so.

vi) The PSR for upstream MTB operations also includes a float-in risk. This potential hazard area extends upstream of the ST. FC located in this area at the time of MTB run initiation at the RIP can float downstream past the ST during the MTB run and be placed at potential safety risk.

The probability that the MTB will encounter FC before the MTB reaches a safe stopping location and before FC float past the ST is calculated using the above fault-tree risk assessment procedures. This assessment is based on MTB operational speeds through different portions of the SOC, operational mode alternatives, and the float speeds of FC in the SOCs. The risk to FC in different portions of the shadow zone may be analyzed separately and then weighted based upon the proportion of the shadow zone that they represent.

2) Probability of Not being Seen (PNS):

The PNS is a measure of the likelihood that, if one FC is in a SOC when a MTB reaches the RIP, the FC will be in a position not observable by the MTB operator. In all SOC/scenarios the PNS is directly proportional to the "length" of the unseen portion of the SOC relative to the total "length" of the SOC as measured along the FC float route and as measured by float time. The ends of the SOCs are set by the RIP and ST locations for downstream operation MTBs and by the RIP and the end of the potential hazard area for upstream operating MTBs.

The PNS computations are found on the SOC/scenario Assessment Plates in Appendix J and the SOC/scenarios PNSs are presented on Table 2.

For each SOC/scenario the PNS has been calculated using one of four methods depending upon MTB LOS thresholds, the number of FC routes, and consistency of FC float speeds on different FC float routes.

a) The basic method of calculating the PNS is to divide the non-visible length of the FC float route by the length of the FC float route through the entire SOC. In this case it is assumed that the FC speeds through the SOC are consistent. The non-visible length or shadow zone is measured from the location that the RIP LOS threshold crosses the FC float route to the end of the SOC along the FC float route. This is typically used for SOCs with one major FC float route (Hellgate Riffle, Argo Riffle, Whitehorse Riffle, etc).

b) Occasionally there are SOCs with multiple FC float routes where the MTB LOS threshold from the RIP crosses the separate FC float routes obliquely. When this occurs, a proportional average is used to calculate the non-seen area to accommodate the different lengths of the separate FC float routes in the unseen area. The proportional PNS is calculated by proportionally averaging the non-seen FC float routes based upon the percentage of FC that use each float route. The method for determining the length of each non-seen float route is the same as referenced above. The total length of the SOC was not proportionally averaged. The total SOC length is measured based upon the MTB route.

c) Occasionally there are SOCs with multiple FC float routes that have diverse FC float speeds. In these cases the PNS is calculated by using FC float times rather than FC float route lengths. This is especially important in SOCs with pop-out risk potential where FC may be entrained in eddies, etc. for substantial periods. The

Table 2

SINGLE-FC SOC ASSESSMENT SAFETY RISK PARAMETERS
Hellgate Study Reach

	Downstream MTB Operations						Upstream MTB Operations					
	Low Flow			High Flow			Low Flow			High Flow		
SOCs	**PNS**	**PSR**	**PMO**	**PNS**	**PSR**	**PMO**	**PNS**	**PSR**	**PMO**	**PNS**	**PSR**	**PMO**
Scenic Section SOCs												
Middleton's Riffle	.429	.507	.218	.388	.064	.025	.437	.832	.364	.394	.890	.351
Applegate	.000	.000	n/a	.000	.000	n/a	.000	.000	n/a	.000	.000	n/a
Whitehorse Riffle	.297	.843	.250	.297	.115	.034	.316	.796	.252	.316	.796	.252
Brushy Chutes	.586	.387	n/a	.491	.010	n/a	.409	.755	.309	.315	.530	.167
Pop-out		.069	n/a		.028	n/a						
Total		.456	.267		.038	.019						
Two Bit Riffle	.000	.000	n/a	.000	.000	n/a	.000	.000	n/a	.000	.000	n/a
Hog Creek Island	.345	.418	.144	.328	.392	.129	.589	.916	.540	.589	.850	.501
Hellgate Riffle	.370	.334	n/a	.374	.207	.077	.342	.727	n/a	.210	.525	.110
Pop-out		.039	n/a					.046	n/a			
Total		.373	.138					.773	.264			
Whitewater Section SOCs												
Dunn Riffle	.369	.073	.027	.369	.073	.027	.101	.513	.052	.101	.513	.052
Ennis Riffle	.000	.000	n/a	.000	.000	n/a	.100	.018	.002	.100	.018	.002
Upper Galice Chute	.313	.053	.017	.313	.053	.017	.776	.198	.154	.776	.198	.154
Pop-out		incl.			incl.							
Lower Galice Chute	.346	.468	.162	.346	.004	.001	.498	.879	.438	.498	.879	.438
Rocky Riffle	.377	.301	n/a	.377	.051	n/a	.415	.584	.242	.415	.584	.242
Pop-out		.026	n/a		.040	n/a						
Total		.327	.123		.091	.034						
Mark's Island	.268	.016	.004	.268	.016	.004	.417	.784	.327	.417	.784	.327
Bailey Riffle	.270	.562	.152	.270	.492	.133	.261	.766	.200	.261	.766	.203
Argo Riffle	.117	.198	.023	.117	.198	.023	.362	.889	.322	.362	.889	.322
Wooldridge Riffle	.038	.043	.002	.136	.002	<.001	.249	.470	.117	.249	.470	.117

Note: Final safety risk parameters for 1992 conditions.

average FC float time through the unseen area is used as a measure of the unseen area and the average FC float time through the SOC is used as a measure of the length of the SOC.

d) For downstream MTB operations, there are a few instances when a MTB has an approach view that, given observed FC float speeds, ensures FC will be downstream of a RIP LOS threshold and out of view when the MTB reaches the RIP. In these cases the potential starting location for FC in the SOC is modified. The starting location of FC is set a distance downstream of the RIP that is determined by multiplying the slow FC speed and the MTB approach time to the RIP. The PNS is then calculated using methods referenced above but using this starting location instead of the LOS from the RIP.

3) Probability of Mutual Occupation (PMO):

In the Single-FC SOC Assessment the PMO represents the probability that a MO will occur if a single FC is in the SOC at the moment that the MTB arrives at the RIP. It is computed by multiplying the PNSs and the PSRs of the SOC/scenarios. The PMO simply states the probability for MOs when a single FC is in the SOC when a MTB arrives. The MOs only occur when the FC is in the unseen portion if the SOC and the MTB run occurs. When the FC is in the seen portion of the SOC it is assumed that the MTB run is not initiated and no safety risks result. The SOC/scenario PMO results are found on Table 2.

E: Multiple-FC SOC Assessment

The Single-FC SOC Assessment procedures, above, assumes that there is one FC in the SOC when the MTB arrives at the RIP. It is used to estimate the probability that the FC is unseen (PNS) and therefore the probability that the MTB will proceed into the SOC, and the probability that a potential accident scenario would result (PSR and PMO). To configure the SOC Assessment so that it can be combined with the FC Use Distribution Model in the SR/C Model such that safety risk exposure can be predicted for a specific management scenario, the safety risks associated with any hypothetical number of FC in each of the SOCs needs to be addressed. This is undertaken with the Multi-FC SOC Assessment procedures.

The Multi-FC SOC Assessment procedure is based on a hypothetical FC use level range (0-50 per 15-minute interval) in each SOC. The assessment predicts for each SOC/scenario: 1) the Probability of Rapid Occupation (PRO) by FC when the MTB arrives at the RIP; 2) the probability that all the SOC-occupying FC are unseen (PNS) and the MTB run is initiated (Probability of run Initiation; PI); 3) the safety risk of a direct MTB run into the SOC (PSR and PMO); 4) the probability that the MTB will have to stop at the RIP to accommodate FC in the SOC; 5) the safety risks of a MTB run after stopping and re-initiating a run; 6) the probable safety risk-related conflict due to wait times; and 7) the physical capacity of SOC.

The Multi-FC SOC Assessment provides two basic products over the hypothetical FC use level range. These are: 1) a Safety Risk Curve that predicts the expected relationship between FC use levels and PMOs and, 2) a Conflict Curve that predicts the relationship between FC use levels and safety risk-related wait incidents. These curves plot a variety of safety risk and conflict parameters over the 0-50 FC use range. Because of other basic BS/C probability modeling assumptions, the safety risk and conflict probabilities apply to the lead MTB craft on each MTB trip through each SOC/scenario. The curve relationships can also be used as a measure of the proportion of MTB trips that could encounter safety risk and conflict conditions at each SOC/scenario over the hypothetical FC use level range.

1) Safety Risk Curves:

The Safety Risk Curves represent the relationship between varying FC use levels (0-50) and the probable degree of safety risk exposure that would occur for each SOC/scenario during all MTB lead craft runs. The safety risks at the various FC use levels are expressed as the PMO. This is the key measure used to estimate the probability of inadvertent safety risks at each SOC. The PMO is determined by utilizing the PNS and the PSR from the Single-FC SOC Assessments and the PRO for Multi-FC as described above. These factors determine: 1) the probability that the operator of an arriving MTB does not see any FC in the SOC and initiates a run directly into the SOC; 2) the probability that at least one FC is observed by the MTB operator and the MTB is stopped to wait for an opportunity to run the SOC; and 3) the total PMO as a composite of the two MTB run scenarios.

The SR/C Model uses the FC Use Distribution Model to determine the number of FC expected at a SOC in a specific 15-minute interval for a specific recreation/management situation and uses the PMO results of the Multi-FC SOC Assessments to predict the MOs that will occur during a MTB run through a specific SOC at a specific time.

a) Probability of Rapid Occupation (PRO); The probability of rapid occupation is the probability that, for any given hypothetical FC use level, one or more FC are somewhere in a particular SOC (seen or unseen) during a 15-minute interval. The PRO results from: 1) the expected number of FC that the FC Use Distribution Model predicts will be in the 15-minute float segment that contains the specific SOC; and, 2) the probability that any of the FC in the 15-minute float segment are in the SOC at the moment the MTB arrives at the RIP. The first factor varies with the FC use level. The second factor varies with both the length of the SOC in terms of average FC float time in relation to a 15-minute period, and the degree to which multiple FC overlap when floating the SOC.

The methodological approach to the PRO is based on three assumptions: 1) the 15-minute float segment to which the expected number of FC are assigned extends from the SOC RIP, through the SOC to a point 15 minutes of average FC float speed past the RIP (for downstream operating MTBs that is from the top of the SOC to a point 15-minute downstream, and for upstream operating MTBs, from the bottom of the SOC to a point 15-minutes upstream): 2) that the expected number of FC in a 15-minute float segment is functionally equivalent to the number of FC that will arrive at the SOC over the a 15-minute interval in which the MTB arrives; and 3) that the approaching MTB has an equal chance of arriving at the SOC RIP at any of the infinite number of moments within the 15-minute interval.

The PRO for any given number of expected FC is calculated by a two step process: 1) determining the typical FC overlap for any given number of FC involved; and, 2) using specific SOC FC float time information to develop the PRO at the time of MTB arrival.

i) Multiple-FC/Time of Occupation Relationship; When only one FC is in a 15-minute interval, or period, it is easy to develop a measure for the PRO for an SOC; the average FC float time through the SOC is divided by 15 minutes. The relationship becomes more complex when multiple FC are involved. When two or more FC are in SOCs at the same time the occupation of the SOC by each FC overlaps with that of other FC. As the number of FC in a SOC increase the total time of SOC occupation by the group of FC increases at diminishing rates. This relationship is very important in determining the PRO.

Five SOCs (Dunn, Ennis, Upper Galice, Lower Galice, and Argo) were analyzed to develop a measure of the time a SOC is occupied with respect to FC use densities. Video tape from these SOCs was analyzed to determine the relationship between FC group size and SOC occupation time. In that evaluation a "group" referred to any spatial grouping of FC that resulted in at least one FC occupying the SOC at all times. The time of occupation was measured starting at the time when the first FC in a string of FC entered the SOC. The time of occupation continued as long as at least one FC was in the SOC and the time of occupation ended when the last FC floated out of the SOC and SOC was completely clear of FC. These FC groups were not necessarily composed of FC on the same recreational outing or part of the same set of individuals. For purposes of the FC overlap evaluation a "group" was simply the distribution of FC that resulted in the SOCs being occupied by at least 1 FC over a protracted period.

For each SOC analyzed, the average time of occupation for each group size was plotted by the average FC float time for each FC in the group as a percentage of the average float time of a single FC (see Figure 28). In general, the riffles and rapids where FC tend to have greater overlap and tendencies to co-occupy will plot at lower positions on this figure. The SOCs that have the least overlap (Lower Galice Chute and Argo Riffle) are those that are shorter and have well defined and organized main downstream currents that carry FC quickly through the length of the SOC. Even with these variations the FC overlap relationships in these very different SOCs are remarkably similar. To create a single FC overlap curve for use in the PRO process all of the data from the five SOCs were combined to create a aggregate overlap curve. Using this aggregated relationship, for any given number of FC in any SOC, the average float time for each FC of the group is shown as a percentage of the average FC float time of the particular SOC under consideration. Therefore if there are 10 FC expected to float through a SOC over a 15-minute

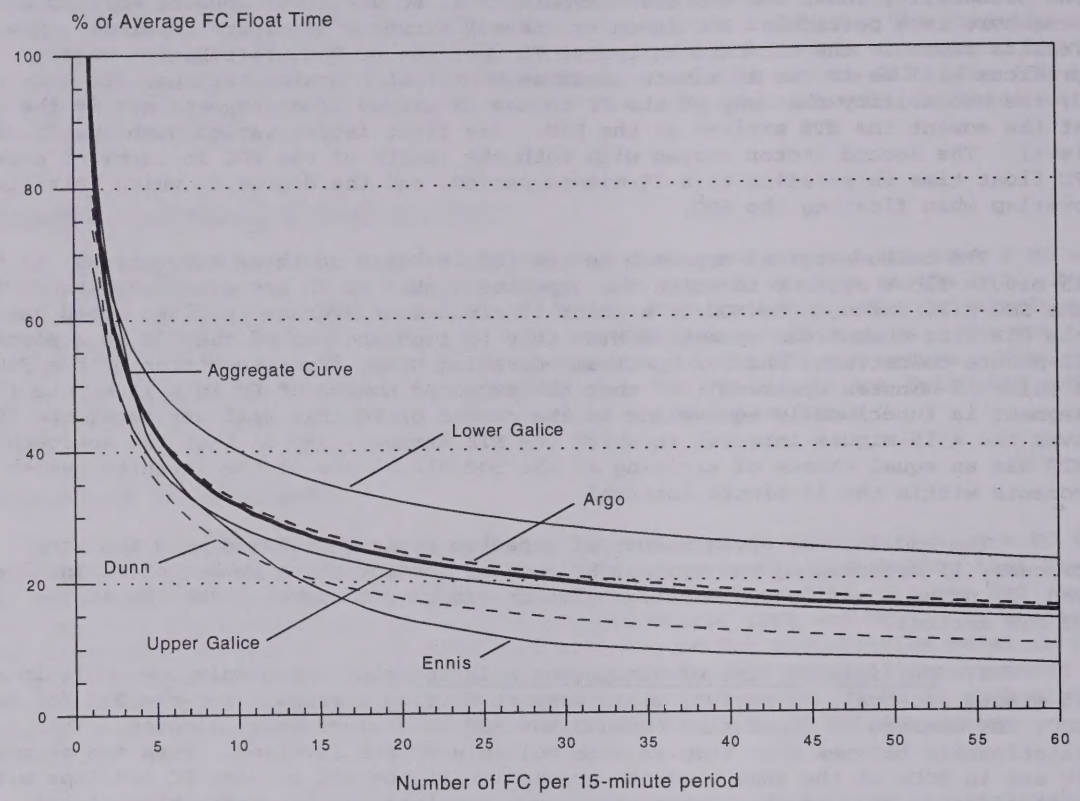


Figure 28

TIME OF OCCUPATION RELATIONSHIP

This figure represents the time of SOC occupation relationship between various potential numbers of FC that may occupy a SOC over a 15-minute period and the average float time, or occupation time, of a single FC.

period, each FC is expected to occupy the SOC for a period of time equal to 31.8% of the average FC float time for that SOC, and when taken together, the 10 FC will occupy the SOC 3.18 times as long as the average single FC.

ii) Computing the Probability of Rapid Occupation; After the FC overlap relationship is determined the PRO is calculated by: 1) determining the total time of SOC occupation for the number of FC involved; and 2) computing the PRO as a ratio between the FC occupation time and 15 minutes.

The total SOC time of occupation for a given number of FC is computed by using the FC overlap relationships, as determined above, and the average single FC float time in the particular SOC being considered. As an example if the 10 FC occupy SOCs at a rate 3.18 times the duration of a single FC and the average float time of a particular SOC is 2.0 minutes, the total time of SOC occupation for the 10 FC is estimated as 6.36 minutes.

When the estimated 6.36 minutes of SOC occupation is compared to a 15-minute period there is a 42.4% chance that the SOC is occupied by at least one FC at any moment during the 15-minute interval in which a MTB reaches the RIP. The PRO for this example is .424.

The average FC float time through each SOC/scenario is computed and the PRO is calculated over the 0-50 FC use level range. Figure 29 shows example PROs for 0 to 50 FC for Middleton's, low flow condition, downstream and upstream MTB operational direction SOC/scenarios. The PRO curve for downstream MTB operations shows that when there are 15 FC expected in a 15-minute interval there is a 50% chance that the SOC is occupied by at least one FC. For upstream MTB operations the 50% PRO occurs when 10 FC are expected in a 15-minute interval. This different in PRO with MTB operational direction results from a change in SOC length. In this case for low flow conditions the SOC is 991 ft. long for upstream operations and 783 ft. long for downstream operations. Line of sight geometry at this SOC and the float-in safety risk component of upstream MTB operations are the causes of increased SOC length (See Plates 2 and 4). Longer SOCs make up a greater proportion of 15-minute float segments and therefore PROs are greater for any given FC use level.

Figure 29 also indicates that SOC length controls the FC use level at which there is a 100% chance that the SOC is occupied. The longer upstream direction SOC shows a 1.0 probability of FC occupation at about 35 FC whereas the shorter downstream SOC reaches a 1.0 PRO at about 55 FC.

b) Probability of Run Initiation (PI); When a MTB trip arrives at a SOC the lead craft will either run directly into the SOC or will stop at the RIP to accommodate FC observed in the SOC. The Probability of run Initiation (PI) is the estimated probability that, for each level of FC use, the lead craft can run directly into the SOC. The inverse of this probability is the probability that the lead craft will stop at the SOC RIP and will wait until the SOC is apparently clear of FC before the run is re-initiated. The SOC Assessment assumes that a MTB will proceed on-plane into a SOC if no FC are observed at the moment a MTB reaches the RIP. Upon arrival, the MTB will proceed directly into a SOC if one of two situations occurs: 1) no FC are in the SOC; or, 2) FC are in the SOC and all FC are unseen from the RIP. The PI is the measure that either of these conditions are met when the MTB arrives; the PI can be represented by the following formula:

PI = (prob. no FC in SOC) + (prob. all FC in SOC are unseen)
PI = (1-PRO) + (PRO*PNS^{FC})

The PNS has been raised exponentially to the power of the number of FC expected in the SOC at the time the MTB reaches the SOC (PNS^{FC}) to accommodate the assumption that all FC must be in the unseen area at the time the MTB run is initiated at the RIP. The number of FC in the SOC at the time the MTB arrives is calculated by the multiplying the number of FC in a 15-minute period by the average FC float time of the SOC expressed as a percent of a 15-minute period. As an example if a SOC has an average FC float time of 2 minutes this is 13% of a 15-minute period, and if 10 FC are expected in a 15-minute period, then the average number of FC expected to be in the SOC when a MTB arrives is (0.13) * (10 FC) = 1.3 FC.

The PI curve on Figure 29 shows the relationship between hypothetical FC use levels and the probabilities that a lead MTB operator will not see any FC in the SOC from the RIP and will run directly into the SOC without stopping. For the downstream operational SOC/scenario there is a 50% chance for an arriving MTB trip lead craft running directly into the SOC at about 18 FC and at about 13 FC for the upstream operational scenario. Therefore at a FC use level of 18 FC per 15-minute interval, under low flow conditions, over enumerable MTB trips, 50% of the lead MTB craft on the downstream legs of trips will run directly through this SOC and 50% will stop to accommodate FC observed in the SOC. The 50/50 split occurs at a use level of 13 FC per 15-minute interval on the upstream leg.

Various attributes of SOCs drive the shape of the PI curves of the SOC/scenarios but the two main factors are the proportion of the SOC that is unseen from the RIP and the total length of the SOC. At lower FC use levels the first attribute drives the probabilities that occupying FC will, or will not be observed. Also at low FC use levels the function of increasing FC overlap with increasing FC use levels creates a PI curve shape that indicates a declining rate of PI reduction with increasing FC until the influence of the FC overlap factor is overcome. Figure 29

shows that for the Middleton's low flow condition SOC/scenario this change in the PI rate of decline occurs at about 8 FC for downstream operations and at about 6 FC for upstream operations.

At higher FC use levels the SOC length controls the FC use levels at which the PRO reaches 1.0. Due to the FC use patterns and SOC characteristics, when the PRO is 1.0 it is more likely that the seen portions of the SOC are also occupied by at least one FC. When the FC use levels are high enough such that the seen portion of the SOC is always occupied by at least one FC the PI is zero. For Middleton's at low flows, the PI zero point for upstream MTB operations is at about 35 FC and for the downstream MTB operations is at about 55 FC.

The relationship between PRO and PI is not always such that the PI reaches zero when the PRO reaches 1.0. In situations where the SOC is relatively long and the seen portion is very short, the probability of MTBs being able to run directly into the SOC upon arrival extends to higher FC use levels than does the point at which the PRO reaches 1.0. For example see Figure 47B for upstream MTB operations at Upper Galice. In this example SOC/scenario the PRO is 1.0 at about 5 FC and the PI reaches zero at about 42 FC. This is due to the FC craft overlap function and a proportionally very short seen portion of the SOC; about 22% (See Plate 46). The coincidence of PROs of 1.0 and PIs of 0.0 at nearly the same FC use level occurs in SOC/scenarios where the seen portions of SOCs are a relatively small proportion of the total SOC lengths.

At each hypothetical FC use level the PI curve represents the probability that MTB trip lead craft enter the SOC directly upon arrival and is used to compute the probability that MTBs stop at SOC RIPs. The inverse of the PI curve represents the varying probabilities that MTB trip lead craft operators observe FC in the SOC and stop at the SOC RIP to avoid MOs. These probabilities for the two MTB SOC run scenarios are used to compute the composite PMO associated with the MTB run scenarios.

c) Probability of Mutual Occupation (PMO); The PMO is the measure of safety risk exposure that could result from a lead MTB craft running the SOC/scenarios at prescribed FC use levels. The total PMO at prescribed FC use levels is the combined safety risk potential and probabilities of two MTB operational scenarios: 1) no FC are observed in the SOC and the MTB runs directly into the SOC; and, 2) at least one FC is observed in the SOC and the MTB stops at the RIP to wait before re-initiating a run.

The operational scenario in which the MTB runs directly into the SOC occurs when no FC are observed in the SOC by the MTB operator at the SOC RIP. The MTB stop and run re-initiation scenario occurs when FC are observed in the SOC and the MTB operator stops at the SOC RIP until the SOC is apparently clear of FC before proceeding. The probabilities for these two operational scenarios vary with different expected FC use levels, as are expressed by the PI curve (see preceding section).

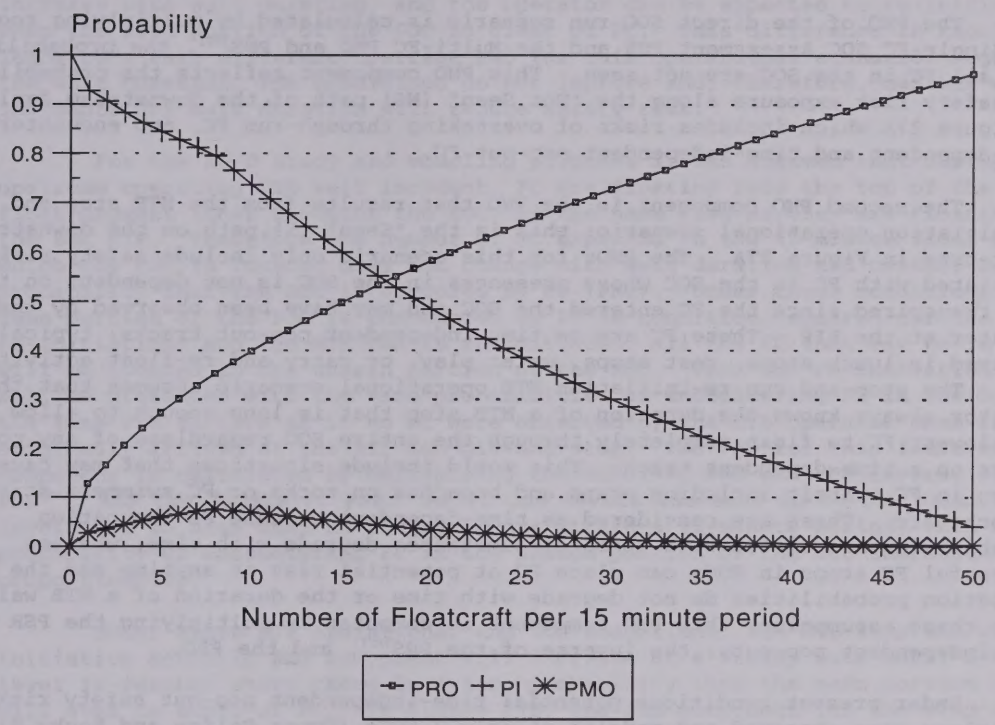
According to the basic modeling rules developed for this BS/C Study the character of safety risk exposures associated with these two operational scenarios are different. The safety risk exposure for the direct SOC run scenario is associated with encountering FC in the SOC that were unseen by, and unknown to, the MTB operator at the moment of arrival. This is limited by the view field from the RIP. Conversely, if the MTB operator stops and waits at the RIP the MTB operator's knowledge of the use activity in the SOC can improve with time. If this knowledge improves, the knowledge field becomes larger than the view field and can lead to a reduction in safety risks. At specific FC use levels the safety risk PMOs of the two operational scenarios are weighted by their probabilities of occurring and combined to form the total SOC/scenario PMO.

Downstream and upstream MTB operational directions through SOCs are fundamentally different with respect to improving MTB operator knowledge fields with duration of waiting at SOC RIPs. When a downstream operating MTB is stopped at a RIP the operator is in a position to gauge the amount of time necessary for any FC observed in the SOC to float to the downstream end of the SOC and to determine when the MTB run can be re-initiated. In this situation, over time the knowledge field extends downstream past the LOS threshold and the view field limits. The MTB operator is also in a position to monitor FC floating into the top of the SOC and can accommodate that activity by extending the stop duration accordingly. When a upstream operating MTB is stopped at a SOC RIP, the operator can only observe FC as

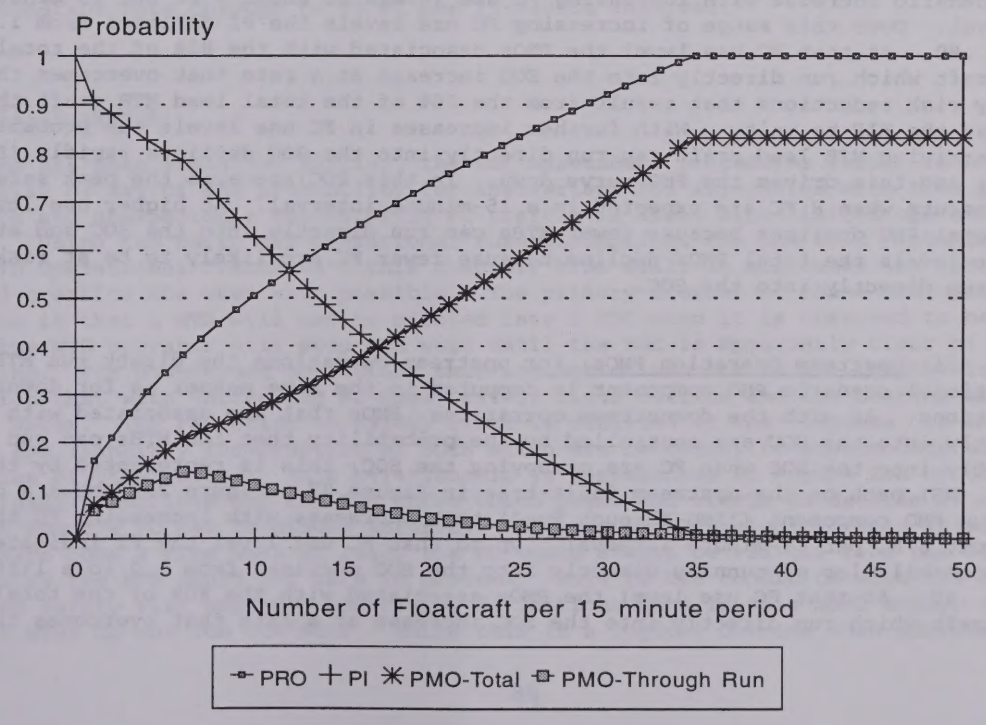
Figure 29

Sample Risk Curves
Middletons - Low Flow Conditions

A. Downstream Operations



B. Upstream Operations



they float into view at the LOS threshold through to the RIP past the stopped MTB. FC activity in the SOC upstream of the LOS threshold remains unknown to the MTB operator regardless of the wait duration. In this case the knowledge field does not improve with time. The varying knowledge field conditions lead to very different PMO results for the MTB stop and run re-initiation operational scenarios for the two operational directions.

i) Downstream Operation PMOs; The total PMO curve for downstream operating MTBs is the sum of the PMOs for the direct SOC run and the stop and run re-initiation operational scenarios when weighted for the relative probabilities for the two scenarios.

The PMO of the direct SOC run scenario is calculated by multiplying together the Single-FC SOC Assessment PSR and the Multi-FC PRO and $PNS^{(FC)}$, the probability that all FC in the SOC are not seen. This PMO component reflects the probability for safety risk exposure along the "Not Seen" (NS) path of the downstream fault-tree in Figure 27A which includes risks of overtaking through-run FC, and encountering time-dependent and time-independent pop-out FC.

The second PMO component is the PMO that results from the MTB stop and run re-initiation operational scenario; this is the "Seen" (S) path on the downstream fault-tree in Figure 27A. The PMOs for this scenario only include safety risks associated with FC in the SOC whose presences in the SOC is not dependent on the time transpired since the FC entered the SOC and may have been observed by the MTB operator at the RIP. These FC are on time-independent pop-out tracks; typically FC involved in lunch stops, rest stops, water play, or carry and re-float activities in SOCs. The stop and run re-initiation MTB operational scenario assumes that the MTB operator always knows the duration of a MTB stop that is long enough to allow even the slowest FC to float completely through the entire SOC regardless of any possible delays on a time-dependent track. This would include situations that may cause long delays in FC transit including wraps and broaches on rocks or FC swimmers stranded on rocks etc. These are considered as time-dependent because FC occupation probabilities associated with these circumstances degrade with time, whereas purposeful FC stops in SOCs can place FC at potential risk at anytime and the occupation probabilities do not degrade with time or the duration of a MTB wait. Under these assumptions this PMO component is computed by multiplying the PSR of the time-independent pop-outs, the inverse of the $PNS^{(FC)}$, and the PRO.

Under present conditions potential time-independent pop-out safety risk situations were observed and modeled at only 2 SOCs (Upper Galice and Rocky Riffle). Therefore in downstream operations most of the total PMO at each level of FC use and for each SOC/scenario is composed of the direct SOC run operational scenario risks with only a small component due to time-independent pop-out situations.

In Figure 29A, the PMOs for the Middleton's low flow, downstream direction SOC/scenario increase with increasing FC use levels to about 8 FC per 15-minute interval. Over this range of increasing FC use levels the PI declines from 1.0 to about .80. At that FC use level the PMOs associated with the 80% of the total lead MTB craft which run directly into the SOC increase at a rate that overcomes the safety risk reductions that result from the 20% of the total lead MTB craft that stop at the RIP to wait. With further increases in FC use levels the probability that arriving MTB lead craft can run directly into the SOC declines rapidly (PI curve) and this drives the PMO curve down. In this SOC/scenario the peak safety risk occurs when 8 FC are expected in a 15-minute interval. At higher use levels, the total PMO declines because fewer MTBs can run directly into the SOC and at lower FC use levels the total PMOs decline because fewer FC are likely to be at risk when MTBs run directly into the SOC.

ii) Upstream Operation PMOs; For upstream operations the direct run MTB operational scenario PMO component is computed in the same manner as for downstream operations. As with the downstream operations, PMOs that are associated with runs directly into the SOC are controlled by the probability that the MTBs can run directly into the SOC when FC are occupying the SOC; this is represented by the 'Not Seen" (NS) path on the upstream fault-tree in Figure 27. Figure 29B shows a direct SOC run PMO component ("PMO-Through Run") that increases with increasing FC through to about 6 FC per 15-minute interval. Up to that FC use level the PI indicates that the probabilities of running directly into the SOC declines from 1.0 to a little under .80. At that FC use level the PMOs associated with the 80% of the total lead MTB craft which run directly into the SOC increase at a rate that overcomes the

safety risk reductions that result from the 20% that stop at the RIP to wait. Similar to the downstream relationship, at FC use levels greater than 6 FC per 15-minute interval, the probabilities of FC being seen by the MTB operator upon arrival increase and the resulting PMOs decline because the probability that MTB craft can follow the direct SOC run operational scenario declines.

As with downstream operations, with increasing FC use levels and increasing PROs, the potential that FC will be observed and the MTB will stop at the SOC RIP increases. However, the changing knowledge field and resulting PMOs for the MTB stop and run re-initiation operational scenario is very different between the two operational directions. When operating upstream and waiting at the SOC RIP, the MTB operator cannot see above the LOS threshold, the operator's knowledge field does not increase with wait duration, and the operator can be expected to re-initiate a run when the seen portion of the SOC is clear of FC. This difference in knowledge field leads to a very different upstream PMO for this operational scenario: Regardless of the wait duration, PSR conditions do not improve and, therefore, neither wait incidents nor wait duration will reduce safety risk.

For the BS/C Study and modeling purposes it was assumed that during a upstream operating MTB wait incident, FC are floating into the top of the 15-minute float segment (that contains the SOC) at the same rate as they are floating out at the SOC RIP. Therefore the number of FC expected in the 15-minute float segment in which the SOC is located does not change with wait duration and neither does the probability that the SOC is occupied by FC (PRO). Under these conditions, when the seen portion of the SOC is unoccupied by FC (a condition required for the MTB run re-initiation) and the MTB run is re-initiated, all the FC that may be in the SOC will be located in the unseen portion of the SOC. Upon run re-initiation, the MTB will be presented with the same probabilities of encountering FC in the SOC and with the same PSR factors as if no FC were observed by the MTB operator when the MTB originally arrived at the RIP and did not stop. The PMO for this fault-tree component is calculated by multiplying the Multi-FC PRO and the inverse of the $PNS^{(FC)}$, and the Single-FC PSR. As FC use levels increase up to the point where use levels are so high that no FC gap occurs within a 15-minute period, then the probability of encountering FC in the unseen portion of the SOC increases proportionally.

Under these MTB operational and SOC conditions, the MTB stop and run re-initiation scenario PMO component will increase at a steady rate until a FC use level is reached where there is a zero probability that the seen portion of the SOC will ever be empty of FC. In Figure 29B, the PMO component for the stop and run re-initiation operational scenario is reflected by the difference between the direct SOC run component (PMO-Through Run) and the total PMO (PMO-Total). The FC use level that imparts a zero probability that the seen portion will be clear of FC (PI= .00) for that SOC/scenario is about 35 FC per 15-minute interval. Above that FC use level no MTB run can occur and the total PMO would drop immediately to zero. For graphic convenience the total PMO curve is shown to artificially remain at a constant rate through to 50 FC per 15-minute interval.

2) Conflict Curves:

As has been explained earlier, the SOC Assessment procedures result in measures of safety risk by way of the probability for inadvertent MOs associated with MTBs proceeding into SOCs and unexpectedly encountering FC traffic in areas with limited operational options. Using the basic MTB operational rule assumptions for the BS/C probability model (See "MTB Operational Practices", this chapter) MTBs will, in all cases, be operated so as to avoid creating MOs when ever possible. The primary element of these MTB operational practices is that a MTB will not be piloted into a SOC when it is observed to be occupied by FC, the MTB operator will stop and wait until the SOC is apparently clear of FC before proceeding. For downstream operations this assumption results in the counter-intuitive conclusion that with increasing FC uses, safety risks decline and the boating situation becomes safer. The reduction in safety risks is realized at the "expense" of increasing waiting and itinerary interruption at SOCs which are necessary to accommodate the activities of other users. This relationship is represented in Figure 29A by the PI curve which steadily declines and the PMO curve which peaks and starts to decline at a FC use level of about 8 FC per 15-minute interval. At some high level of FC uses at any of the SOCs, there come a time when at least one FC would always be visible from the RIP and by these rules the MTB would not able to proceed. This is the condition with the least predicted safety risk exposure because by definitions used in this BS/C Study, no MOs can occur if MTBs do not run the SOCs. While this is a logical outcome when addressing only

the safety risk component of the BS/C recreational environment, it does not account for safety risk related conflicts nor the potential inducement of Overt MOs that could result from increasing wait-related interaction at SOCs.

The flipside of modeled safety risks is the wait related MTB accommodation of FC necessary to avoid MOs and the safety risk-related conflicts that are generated by these wait incidents.

The SOC Assessments assume that an approaching MTB will wait when a FC is observed in a SOC, thus avoiding Overt MOs. It was also assumed that a MTB that does stop and wait at a SOC, will wait until a sufficient gap occurs between FC before proceeding into the SOC. The actual on-river MTB and FC behavior pattern that develops in dealing with a MTB wait incident may vary. Possibilities include:

1) the MTBs can stop and wait for a gap long enough to allow safe MTB passage through the SOC;

2) the MTBs can attempt to hold up FC traffic to create a usable gap between FC that will allow the MTB to proceed;

3) FC can voluntarily hold up or otherwise accommodate MTBs allowing the MTB to proceed; and,

4) a MTB operator can initiate the run by accepting lower safety margins i) between navigational obstacles and the jetboat, and/or ii) between the jetboat and FC.

Each of these possibilities involve accommodations by either FC users or MTB operators/passengers through changes or modification in use patterns, behavior and/or, personal standards of acceptable resource conditions. They are all considered adverse occurrences with respect to safety risks or conflicts because: 1) if they occur frequently enough, these accommodations can lead to recreational resource value degradation and on-river conflicts; and, 2) should FC and/or MTB craft operators elect to continue their SOC uses with reduced margins of safety, additional safety risk situations could develop at SOCs. The first three can be considered as elements of degraded recreation resource values between users. They can evolve into safety risk-related conflicts if they occur frequently enough or create incidents of accommodation of some substantial duration. As "wait incidents" are accumulated by MTB and/or FC users on a particular trip and resource conflicts accumulate, behavioral changes can be expected that could lead to overt safety risk situations. The fourth possibility above, would be considered as an Overt MO in a SOC and would constitute a safety risk created by imprudent MTB operations.

The concept of "wait related conflict" was developed to balance the attribute of declining safety risks with increasing FC use levels. In this portion of the SOC Assessment, conflicts are assumed to be those that are safety risk-related; those that can be defined as potentially leading to induced safety risk problems. Examples of this conflict type include items 1-3 above.

All of the possible conflict circumstances envisioned by the foregoing concept of conflict involve MTB and FC interaction at the entrances of SOCs and the accommodation of one or another user activity group necessary to avoid Overt MOs. The trigger that determines the possibility that these types of conflicts may occur is related to the number of FC that are expected in the area of a SOC at the time of a MTB arrival. Therefore total wait related conflicts are assumed to be directly related to predicted MTB wait requirements at SOCs. Although this approach to safety risk-related conflicts only deals with MTB waits, the "conflict" measure is assumed to be applicable as a total measure of conflict that is incurred by any or all user groups. Therefore "MTB waits" was chosen as a surrogate measure for total safety risk-related conflicts that may be realized by all user activity types.

The various conflict parameters are plotted as "Conflict Curves" which are in the upper portion of the SOC/scenario Safety Risk/Conflict Curve figures (See Figure 30). The Safety Risk/Conflict Curves also have the safety risk parameter plots of the "Safety Risk Curves" described in the proceeding section.

In addition to predicting levels of safety risk-related conflict this assessment approach provides information on the possible physical carrying capacity of individual SOCs.

a) Wait Related Conflicts; In this conceptual approach to safety risk-related conflicts, the probability and magnitude of conflicts over a range of possible FC use levels (0-50) results from several measures of "MTB waits". There are two elements of MTB waits that can be calculated and used as measures of conflict, these are the probability that waits will occur, and the duration of the wait incidents.

i) Probability of MTB Waits; This is the probability that a MTB will have to stop and wait before entering any SOC over the hypothetical FC use range. Since MTBs are assumed to proceed into a SOC without stopping if no FC are observed by the MTB operator at the SOC RIP, the probability of stopping upon arrival is the inverse of the probability of run initiation (PI).

Figure 30B is an example Safety Risk/Conflict Curve for the Middletons-upstream operations-low flow SOC/scenario. The bottom portion of the figure is the Safety Risk Curve that resulted from the safety risk assessment reviewed in the above section. In that portion of the figure the run initiation curve (PI) has been inverted to produce the Probability of Waiting curve (PWait) which reflects the probability of lead MTB craft stopping at the various hypothetical FC use levels. The "probability" is also a measure of MTB stopping frequencies: As an example at 10 FC, there is a 37% chance or probability that a lead MTB will stop in this SOC/scenario and, over enumerable MTB trips about 37% will have to stop. In general the more frequently stop and wait incidents occur the higher is the conflict level for all user groups.

ii) Duration of Waits; Once a MTB has stopped, the duration of the wait is an important element in safety risk-related conflicts. The duration of the MTB wait is the expected time elapsed before a gap occurs between FC large enough to allow a MTB run to be re-initiated based on the MTB operational rules assumed in this BS/C Study. Conflict levels for all user groups increase as the expected duration of the wait incident increase. There are five parameters of wait incident duration. Methods used to estimate the duration of wait incidents vary with MTB operational direction because of the different knowledge fields available to the MTB operator.

(1) Adequate Gaps; The wait related issues below are in part related to the time gaps between FC that would be adequate to allow a stopped MTB to re-initiate a run for each SOC/scenario. The minimum time gaps are related to the MTB operator's knowledge field and the MTB operator's assumption that, based on the best information available, the SOC is clear of FC. This varies with MTB operational direction.

For downstream operating MTBs the minimum time gap that would allow the MTB operator to re-initiate a run after stopping would be the average FC float time from the RIP to the ST. This is because the operator can estimate the float time that observed FC would need to clear the ST and can monitor FC floating past the RIP while the MTB is stopped. The operator's knowledge field extends from the RIP to the ST and the entire SOC must be assumed to be clear before run re-initiation. For upstream operating MTBs the minimum time gap that would allow stopped MTBs to re-initiate a run would be the average FC float time from the LOS threshold to the RIP. This results from the MTB operator's knowledge field being limited by the LOS and not being able to monitor FC that may be in the SOC above the LOS threshold.

The different knowledge fields for the two MTB operational directions imply that for any given SOC the minimum adequate time gap necessary to re-initiate a run is shorter for upstream operating MTBs.

(2) Minimum Wait Time; A minimum MTB wait time occurs when only one FC is in the SOC and it is observed by the MTB operator. In the SOC Assessment this is an average minimum wait time because it is based on: 1) average FC float speeds in the particular SOC; and, 2) the assumption that on average the MTB will reach the SOC when the observed FC is at the mid-point of the observable field of the SOC from the RIP. This represents the average minimum wait time for all stopping lead MTBs that may encounter FC floating at any of the observed float speeds and positioned at any of the different possible locations in the view field when first observed by the MTB operator.

For downstream operating MTBs, the minimum wait is calculated using the average FC float time from the mid-point of the visible field in the SOC through to the ST at the bottom of the SOC. This assumes that on a long term average, a single FC will be located at the mid-point of the MTB operator's view field when the MTB arrives and, following "best" MTB operational practices, the MTB run will not be re-initiated until, in the judgement of the operator, sufficient time has elapsed that allow the average FC to float past the ST.

For upstream operating MTBs, the minimum wait time is calculated using the average FC float speeds from the mid-point of the view field in the SOC through to the MTB RIP. As with downstream operations, this assumes that on a long term average a single FC will be located at the mid-point of the MTB operator's view field when the MTB arrives. However since FC are floating against the MTB operational direction, they float toward the MTB set-down area at the RIP. The MTB operator can not see above the LOS threshold that creates the SOC situation and therefore can not monitor FC that may be floating into the SOC from above. This limits the lead MTB operator's knowledge field to the visible portion of the SOC.

The different MTB operator knowledge fields for the two operational directions results in the general conclusion that minimum wait times for upstream MTB operations are shorter than for downstream operations but for upstream operations there is a greater probability of MOs occurring upon run re-initiation.

(3) Maximum Wait Time; The maximum wait time occurs when FC use levels are high enough to create FC use pattern densities such that no gaps remain that are large enough to be used by the MTB to run the SOC. This maximum wait condition is defined when no usable gaps occur over a specified time period. As a result of on-river field work, as well as time segments of other SR/C Modeling components, a 15 minute period was assigned as the duration threshold for maximum waits; any waits equal to or longer were considered as a condition that exceeded the physical capacity of the SOC/scenario. The FC use level that results in the maximum wait time for each SOC/scenario is a product of: 1) the relative size of the SOC view field and MTB operator's knowledge field (as in (2) above); 2) the average FC float speeds in the particular SOC; 3) the assumption that on average the mid-point of the FC group that causes the MTB to stop will be at the mid-point of the SOC view field when the MTB arrives at the RIP; 4) the overlap of FC craft in groups (See Figure 28) and, 5) the spatial distribution of FC over a 15-minute period (See (4) below).

(4) Wait Duration; The wait duration is simply the typical average duration of wait incidents over the hypothetical FC use level range. While the wait duration depends on the various physical and float speed parameters listed in (1) and (2) above for each SOC/scenario, the spatial distribution of FC involved can result in widely different wait durations. The probability that FC are in the SOC and are observed when the MTB arrives at the SOC determines the probability that a wait incident will occur. As FC use increases the probability and frequency of wait incidents also increase.

Once stopped, the opportunity for the MTB to re-initiate the run depends on the presence of a gap between FC large enough for the MTB to proceed. For any given FC use level, the presence of an adequate time gap is related to the spatial distribution of the FC on the river. If the FC involved are grouped together when running the SOC (no adequate gaps between individual FC) there is only one usable gap that gradually gets smaller with increasing FC use levels. If the FC involved are evenly spread out through the 15-minute period when running the SOC there will be as many usable gaps between FC as there are FC and, with increase FC use levels, the gaps between individual FC will become more numerous and smaller.

Field data collected in the 1992 season did not provide any highly consistent picture of FC craft spatial distribution. Field observation indicated that patterns varied between SOCs and at SOCs at varying times. While many FC craft ran SOCs as individuals, most ran in small groups, and occasionally very large groups (usually commercial) would run in a very tight group with very large gaps between other groups. In general it was determined that no single FC craft spatial distribution pattern would be appropriate. As a result the expected wait incident duration was calculated for every SOC/scenario for both "0% Clumped" and "100% Clumped" FC spatial distribution assumptions. It was assumed that these two spatial distribution patterns bracket the actual FC distribution pattern that may occur in any SOC/scenario at any time.

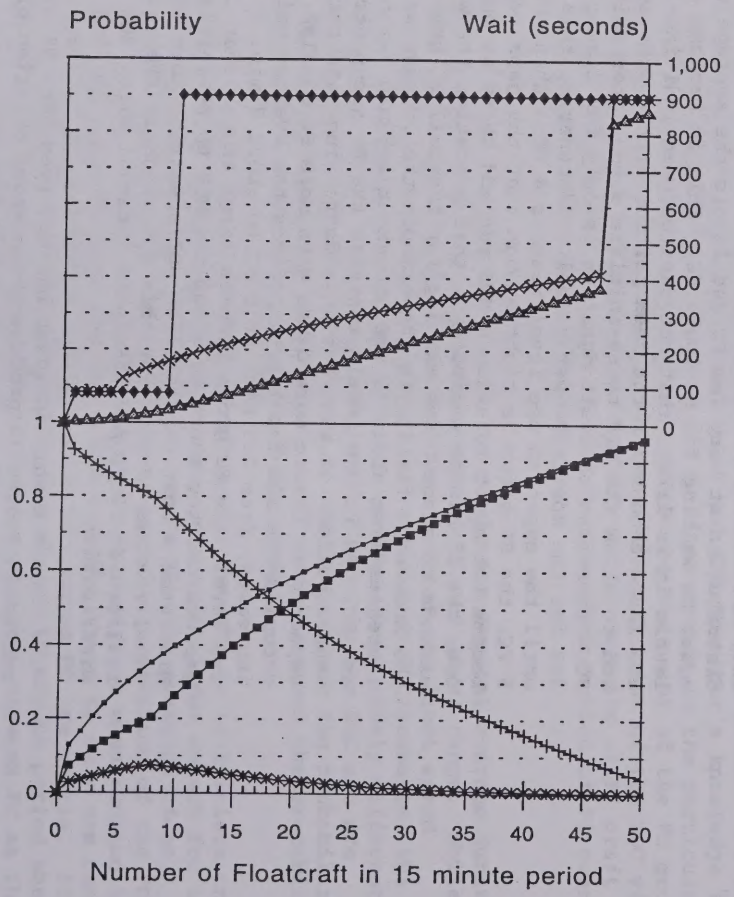
"0% Clumped" - If all individual FC that float the SOC in a 15-minute period are evenly spaced they are defined as 0% clumped. At low FC use levels, should a MTB stop at the RIP, this distribution provides gaps between FC adequately large for MTBs to re-initiate a run after each FC. Therefore the average wait time is associated with that time necessary to wait for a single FC to clear the MTB operator's knowledge field. Thus average wait duration can be short; as short as approximately 30-50 seconds for upstream operations at SOCs with short knowledge fields (See Figure 30B; "Wait-0% Clumped"), to several minute (5-7 minutes) for downstream operations at long SOCs. As FC use levels increase the number of gaps increase proportionally and they all get smaller evenly. Through some range of FC use levels the average wait duration stays the same because the MTB is always waiting for only one FC before an adequate time gap occurs. In Figure 30B, the "Wait-0% Clumped" curve shows that for the upstream operational SOC/scenario, no increases in average wait duration occur until about 7 FC are expected. When the use level increases to 8 FC, all the gaps between the FC become too short to allow the MTB to re-initiate a run. For this SOC/scenario with 0% clumped FC distribution, the maximum wait time is realized at 8 FC.

"100% Clumped" - If all FC that float the SOC during a 15-minute period have a distribution that creates only one large gap, they are defined as being 100% clumped. With this FC spatial distribution at very low FC use levels the average wait duration is equal to waiting for a single FC. This is because at these low use levels it is likely that the gaps between individual FC in the group are large enough for the seen portion of the SOCs to be empty of FC and to allow the MTB to re-initiate a run after waiting for only one FC. Therefore the wait duration is only for a single FC. In Figure 30B for the upstream operational SOC/scenario, this is the situation until the expected use level reaches 4 FC. When the use level reaches 5 FC, the FC group is tight enough that the gaps between individual FC become too short to allow a MTB run and there is only one adequate gap over the 15-minute period. In this situation the wait duration extends to accommodate waiting for the full FC group to float through the knowledge field. In the example the average wait duration increases from about 35 sec. to about 2.5 min. with the addition of one FC. As FC use levels increase the FC group occupies the SOC for longer periods of time but at a decreasing rate because the FC are expected to become more dense with more FC overlap. As the FC group occupies the SOC for longer periods the average wait duration increases; from 2.5 min. at 5 FC to about 7 min. at 29 FC. At some FC use level, the FC group becomes large enough that the single remaining gap becomes too short to allow the MTB to re-initiate a run. For the Middleton's upstream low flow SOC/scenario, this occurs when the use level reaches 30 FC. For this SOC/scenario the maximum wait time is realized at 30 FC per 15-minute interval with 100% clumped FC distribution.

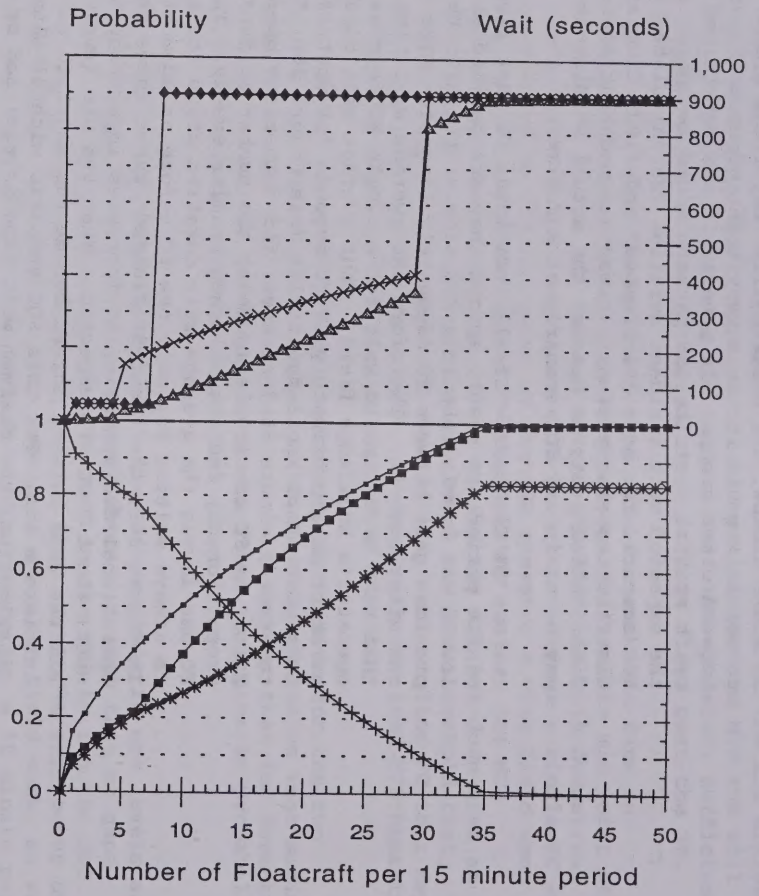
Once a wait incident has occurred, the 0% and 100% clumped wait curves in Figure 30 predict the average duration of wait incidents over the hypothetical FC use level range.

Figure 30
Safety Risk/Conflict Curves
Middletons
Low Flow Conditions

A. Downstream Operations



B. Upstream Operations



PRO PI PMO PWait Wait - 100% Clumped Wait - 0% Clumped MTB Wait

(5) Expected MTB Wait Duration; This parameter is the average MTB wait duration for each and every lead MTB arrival for each SOC/scenario over the range of FC use levels. This combines the important safety risk-related conflict parameters; the frequency or probability of wait incidents occurring, and the average duration of waits should they occur. The expected wait duration is derived by multiplying the Probability of a Wait Incident (PWait) times the average wait duration for a given FC spatial use distribution pattern.

Based on observations in 1992 it is estimated that "a typical" FC spatial distribution and associated waits are more reasonably characterized by assuming that FC are running as 100% clumped. The expected MTB wait duration results from combining the average wait duration for 100% clumped FC distribution with the probability that wait incidents occur. This is shown by the "MTB Wait" curve in Figure 30. At very low FC use levels both the probability of wait incidents and average wait durations are low. For the example upstream operation SOC/scenario, the average wait duration with each and every lead MTB arrival will be less than one minute through a FC use level of about 9 craft per 15-minute interval, and at FC use levels of about 29 FC per 15-minute interval, the expected wait time for each and every lead MTB arrival will average about 6 minutes.

These wait parameters are assumed to represent mutual safety risk-related conflicts associated with the use of the SOCs at various FC use levels. The conflicts may be accrued by the MTBs in the form of waits and interruptions to the itineraries or accrued by the FC in the form of accommodating passing MTBs (or any combination). Therefore, although characterized in the SOC Assessment process by the waiting patterns of MTBs in accommodation of FC at SOCs, the resulting conflict measures are intended to represent conflicts to all user groups.

b) SOC Saturation; Based on some assumed threshold for acceptable wait duration the physical capacity of each SOC/scenario can be determined. This BS/C parameter is explored in this BS/C Study but is not used as part of the risk probability model output. For the purposes of this BS/C Study the "physical saturation point" is defined as a FC use level condition that, over an entire 15-minute interval, provides for no gap between FC of sufficient size to allow a run re-initiation for all MTB trip arrivals. These physical saturation points will vary among the SOC/scenarios based on: 1) length of SOCs which drives the number of FC in the SOC; 2) the length of SOCs and the LOS threshold patterns which drive the size of the time gaps necessary to allow adequate MTB runs; 3) the MTB operational direction which controls the change in the operator's knowledge field and thus the time length of adequate gaps; and, 4) the spatial distribution of the FC which controls the pattern of gaps at any given FC use level.

Based on the foregoing definition of physical saturation the probability that once an MTB is stopped no adequate gaps will occur over a 15-minute interval is the same as a zero probability that the seen portion of the SOC will be unoccupied by FC at each moment of a 15-minute interval. Therefore physical saturation is defined by that FC use level that creates a 100% chance that each arriving MTB trip will have to stop before running the SOC. In the upstream operational example in Figure 30B physical saturation occurs at about 40 FC. At that FC use level a wait incident will occur with all arriving MTB trips and all the wait incidents will have a duration of 15 minutes or longer. This is an extreme capacity condition, far beyond what which may be normally considered as an appropriate recreational resource value threshold; therefore it is referred to here as "physical saturation".

This physical saturation assessment approach can be used in conjunction with other user preference and management agency recreation quality objectives to estimate carrying capacity levels for each of the SOC/scenarios. To extend this to issues of carrying capacity, standards and thresholds of acceptability would need to be developed for the user activity types in the study reach or if appropriate, by study reach section. As an example if, for any recreation management reason, it is concluded that the average wait incident duration for each and every arriving MTB trip at a SOC should not exceed 5 minutes, each SOC/scenario could be evaluated for the FC use level that leads to average waits of 5 minutes in duration; in Figure 30B for the upstream operational direction that situation would occur with about 25 FC.

If it is concluded that no wait incident should exceed 5 minutes in duration the capacity of the upstream operational SOC/scenario in Figure 30B would be between 7 FC (at 0% clumped) and 17 FC (at 100% clumped). Using whatever recreation capacity parameters are developed, these FC use levels could be defined as the carrying capacity limits of that SOC/scenario. The assessment approach could be extended to routing a MTB trip itinerary schedule and determining when the total number of wait incident and total duration of waits have exceeded some established thresholds. These carrying capacity applications were not undertaken as part of this BS/C Study.

PART III: GOLD HILL STUDY REACH

F: Gold Hill Study Reach SOCs

SOC Assessments undertaken on the Gold Hill Study Reach followed the same basic approaches as were used on the Hellgate Study Reach. However, the very limited field and sample days available for the Gold Hill Study Reach dictated that the SOC Assessment results would be qualitative instead of quantitative. As a result the full application of the probability based SOC Assessment and SR/C Model methods developed to predict management scenario safety risks was not feasible in this portion of the study area at the time.

The approach used in the SOC Assessments on the Gold Hill Study Reach was as follows. The MTB set-down threshold locations, drifting reaches and operational shoals were identified for each SOC/scenario in workshop sessions with the MTB owner/operator using aerial photos, during on-river reviews with the Jackson County Marine Deputy using a patrol JB, and through very limited site depth sampling by WRC-Environmental field staff. The operational depths were the same as those used on the Hellgate Study Reach: set-down thresholds, 3 ft.; drifting, 1.5 ft. to 3 ft.; on-plane operation limits, > 0.75 ft.

RIPs and STs were located using the assumed MTB PSDs and SSDs for "Small" sized MTBs as explained in PART I and PART II of this chapter. LOSs and LOS thresholds were established using the RIPs as points of LOS origin. The fault-tree procedures described in PART I were used to determine MTB operator decisions and to route the lead MTB craft through the SOCs. The MTB operational times between RIPs and STs were calculated based on assumed MTB operational on-plane speeds of 20 mph through the SOCs and drifting speeds at 1.5 time the average FC float speeds. The degree of potential safety risks were estimated by determining the FC float speed threshold that allowed an unseen FC (from the MTB operator positions at the RIPs) to float to the ST before the MTB arrived at the ST. The relative estimate of safety risk was based on the portion of FC that are likely to be faster or slower than the identified FC threshold float speeds. Were appropriate, MTB operational changes that could enhance safety are presented. The results of the SOC Assessments on the Gold Hill Study Reach are presented on Plates 67-74 in Appendix J.

PART IV: SAMPLE SOC ASSESSMENT PLATES

The following section contains sample SOC Assessment plates from each of the study reaches; these are SOC Plates referenced in the report text. Hellgate Study Reach SOCs are in Plates 2-66 and Gold Hill Study Reach SOCs are in Plates 67-74. Plate 1 is a legend/key plate. For each SOC the different SOC/scenarios are assessed separately only if channel/ hydraulic conditions or user patterns are different. The complete set of all SOCs for both study reaches is found in Appendix J.

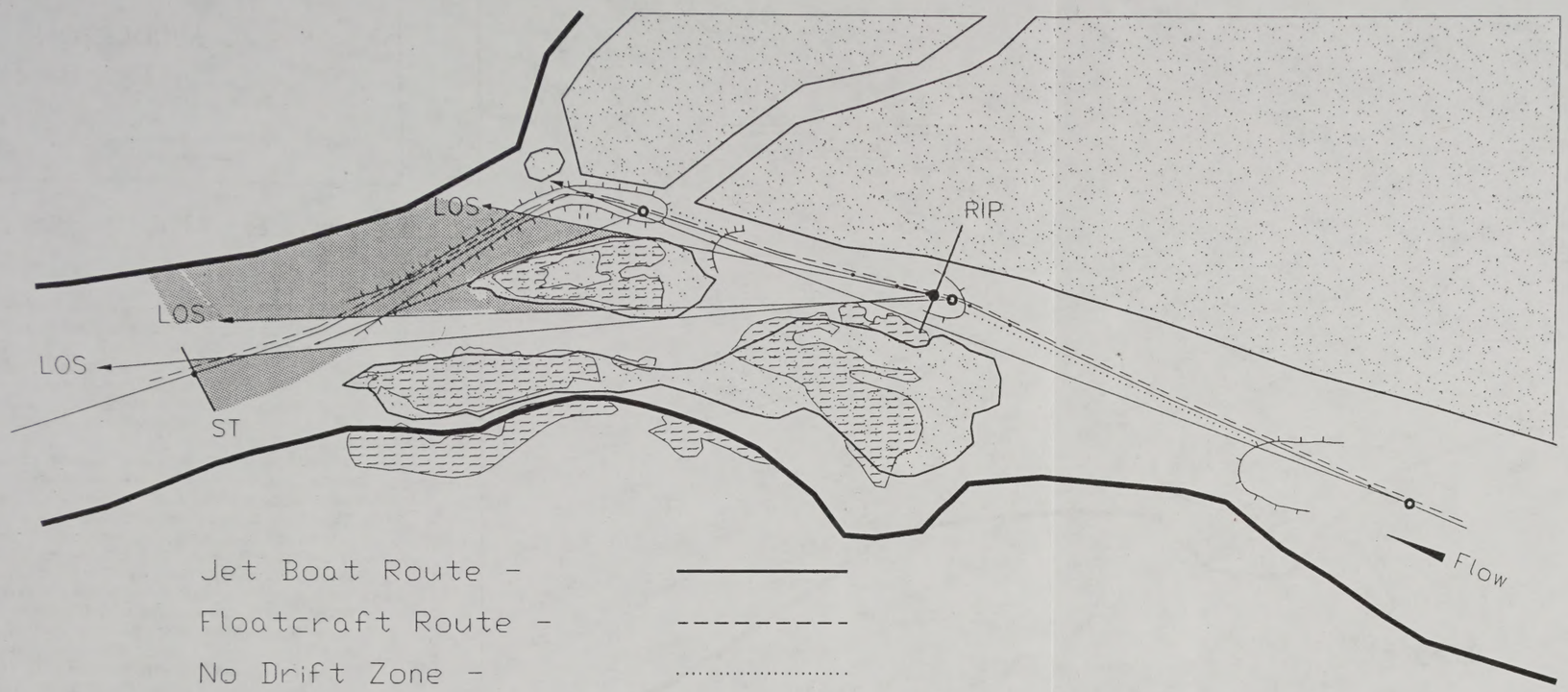
Rogue River Boating Safety and Conflicts Study
SOC Analysis

LEGEND

Prepared by: WRC-Environmental
Sacramento, CA

MTB Operational Direction

Discussion of pertinent channel features, MTB/JB operations, FC patterns, line of sight issues, and risk elements.

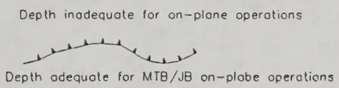


Jet Boat Route - ———

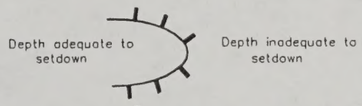
Floatcraft Route - - - - - - - - -

No Drift Zone - .....

Shoals -



Setdown Area -



Mid-channel Islands -

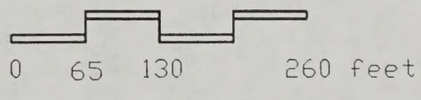
Vegetation -

Hazard Zone -

RIP - Run Initiation Point

ST - Safety Threshold

LOS - Line of Sight



BLM Library
Denver Federal Center
Bldg. 85, OC-521
P.O. Box 25047
Denver, CO 80225

Assumptions:

		Source
Slow FC Speed:	ft/sec	Source of Speed information for FC
Ave FC Speed:		If alternate location used for speeds
Fast FC Speed:		location, timeline, and distribution will be referenced
MTB Speed:	ft/sec	Source of speed information for MTBs
Other:		

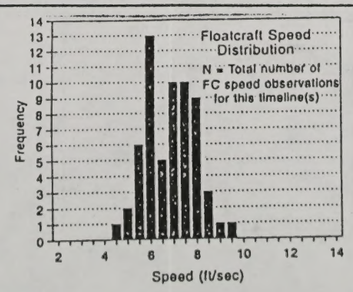
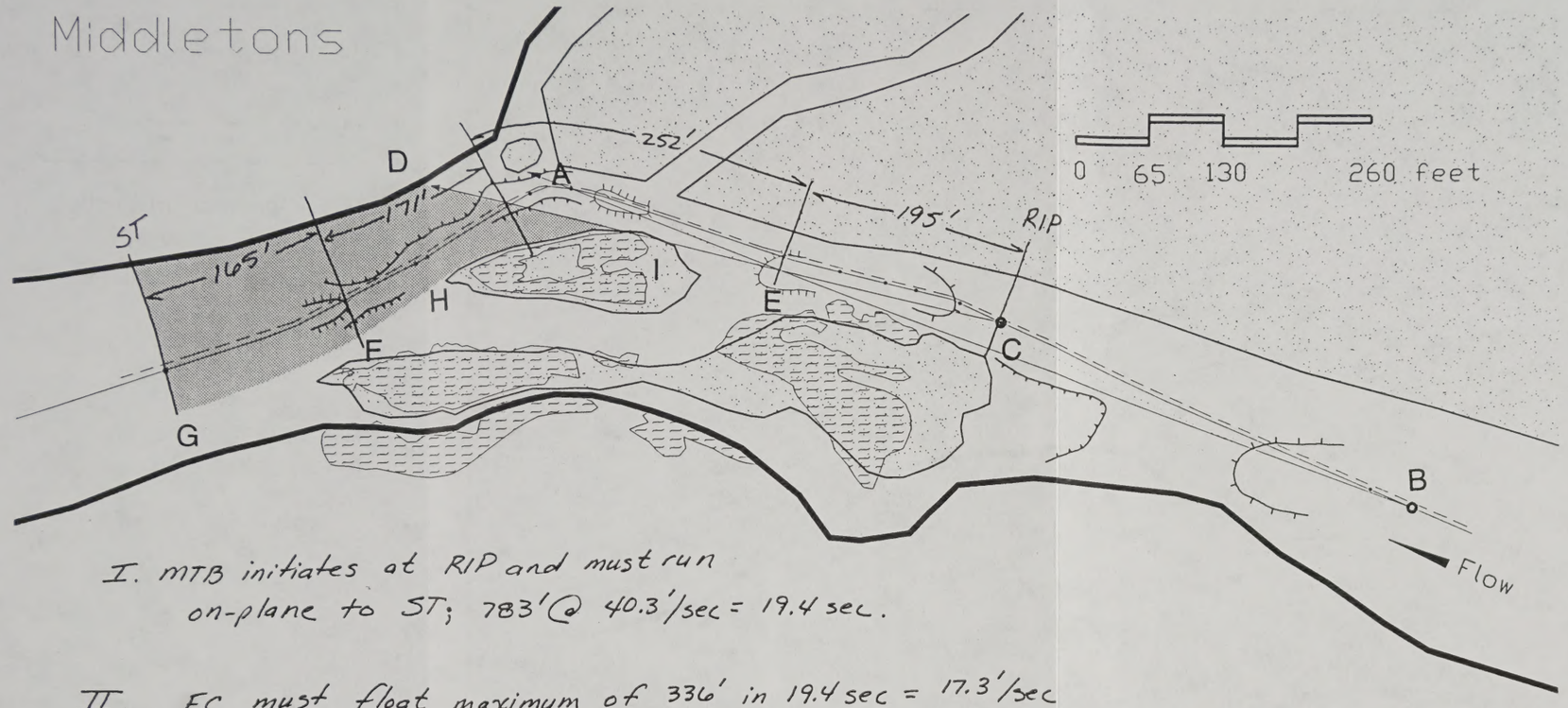


Plate 1



I. MTB initiates at RIP and must run on-plane to ST; 783' @ 40.3'/sec = 19.4 sec.

II. FC must float maximum of 336' in 19.4 sec = 17.3'/sec (No FC observed this fast)

Reach that FC have chance to reach ST =

$FC_{fast} \times 19.4\,sec = 11.9'/sec \times 19.4\,sec = 231'$

III. PSR = (Risk where FC have chance to reach ST) + (Risk in reach where no FC can reach safety)

$= \frac{231}{336}\left(1 - \frac{FCave}{FCfast}\right) + \frac{105}{336}(100\%)$

$= .688\left(1 - \frac{8.53}{11.9}\right) + .312$

$= .688(1 - .718) + .312 = .688(.282) + .312 = .195 + .312 = .507$

IV PNS = $\frac{336}{783} = .429$

Assumptions:

		Source
Slow FC Speed:	3.56 ft/sec	FC speed distribution assumed to be similar
Ave FC Speed:	8.53 ft/sec	to T1–T3 at Lower Golice. Assumption checked
Fast FC Speed:	11.9 ft/sec	in field with float through in canoe.
MTB Speed:	40.3 ft/sec	Assumed similar to speeds in Lower Golice T1–T3.
Other:		

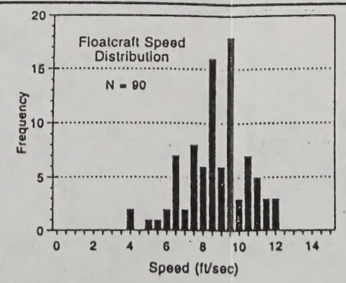


Plate 2

Rogue River Boating Safety and Conflicts Study
SOC Analysis

MIDDLETONS
Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA

Downstream MTB Operation

Approach visibility: Although point **A** is visible from points farther upstream it is only continuously visible from point **B** about 425 ft. above the RIP at **C**. At 27.4 mph, there is 10.5 sec. of MTB run time from **B** to **C**. FC would have to float the 54 ft. from **A** to LOS **D** in 10.5 sec (5.1 ft/sec.) or faster to make **B** a more critical visual location than **C**. FC speeds indicate about 3% of the FC are slower than 5.1 ft/sec; typical FC speeds indicate the critical SOC visibility is from the RIP at **C** along LOS **D**.

RIP: The RIP is set 195 ft. above stopping point **E** to accommodate reaction time, and PSD in a 'narrow' set-down. MTBs can not drift through to the tailwater at **F**. The RIP sets the origin of LOS **D**.

ST: The ST at **G** is set by a SSD of 165 ft. below the set-down threshold at **F** to accommodate PSD plus craft separation.

PNS: From the RIP to the ST 42.9% of the SOC is below LOS **D**. Based on FC route distribution the PNS is 0.429.

PSR: Safety risk is a result of a through-run condition:

Through-run: FC are between LOS **D** and the ST at **G** when the MTB passes the RIP: The MTB operating time to the ST is 19.4 sec at 27.4 mph. FC speed distribution indicate the fastest FC can float 231 ft. in 19.4 sec. Above point **H** all FC will be overtaken by the MTB. The reach between LOS **D** and **H** is 31.2% of the unseen area. The weighed PSR for the area above **H** is 0.312. Below **H** being overtaken is a function of FC location at the moment the MTB passes the RIP and FC speed. FC speed distribution indicates that 71.8% of randomly located FC between **H** and **G** will be able to float past **G** before being overtaken and 28.2% will be overtaken. The reach between **H** and **G** is 68.8% of the unseen area. The weighed PSR for the area below **H** is 0.195.

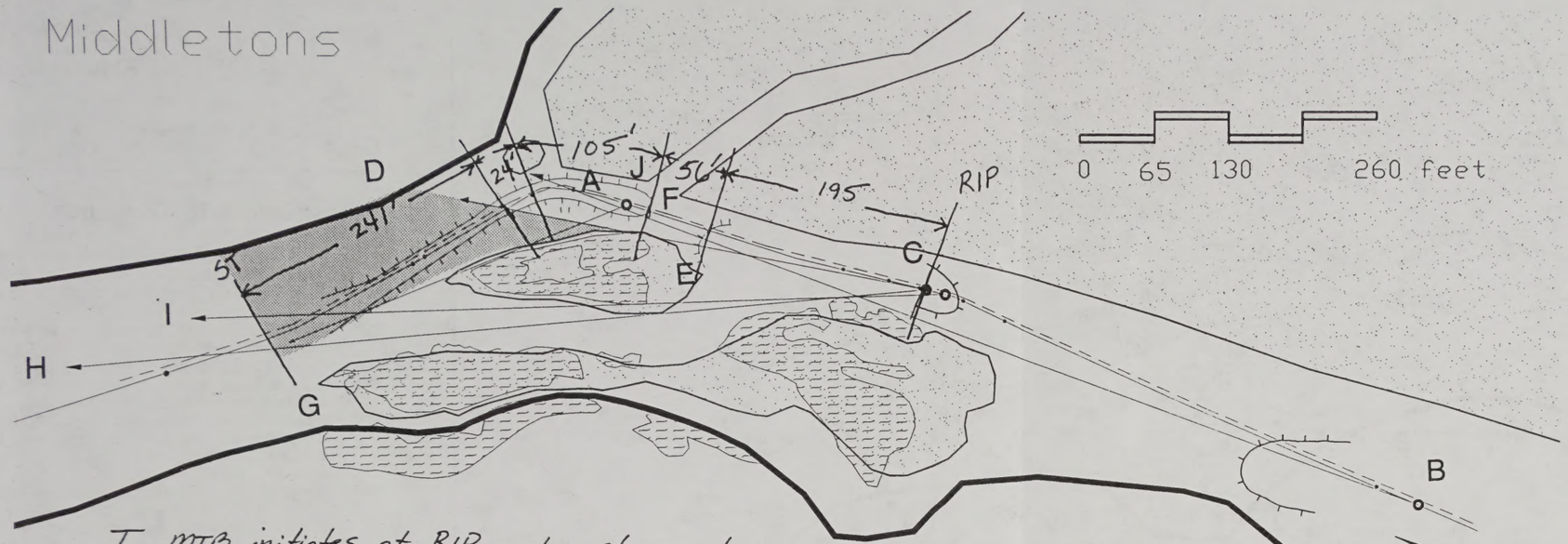
The total PSR is (0.312)+(0.195)=0.507

Notes:

Vegetation management over the island at **I** could reduce the PNS to zero and the PSR to zero.

FC speed distribution estimates are taken from other SOCs; deviations in actual Middleton FC speed could alter PSR results.

About 25% of observed driftboats had delayed transits, spending from 15 to 30 minutes between **F** and **G** fishing the tailwater and shoal areas. This would be a non-time dependent pop-out safety risk element and would increase the PSR.



I. MTB initiates at RIP and must operate 621' to ST. ST chosen because it is the first location the channel is wide and deep enough for both MTB and FC to mutually occupy an area and be under control.

MTB operates on-plane and can initiate setdown at J; total setdown at K

MTB operates 356' on-plane at 40.3'/sec = 8.8 sec

MTB drifts 265' at FCave(1.5) = 265 at (1.5x8.8'/sec)
= 265 ÷ 12.75'/sec
= 20.8 sec

total run time = 8.8 + 20.8 = 29.6 sec

II. FC must float a maximum of 241' in 29.6 sec = 8.14'/sec

FCsafe = 8.14'/sec

III. PSR = (1 - Psafe)

$= \left(1 - \frac{FC_{safeave}}{FC_{safe}}\right)$

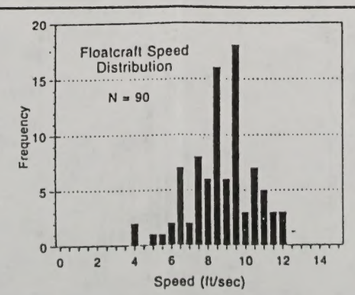
$= \left(1 - \frac{7.62}{8.14}\right)$

= (1.0 - .936) = .064

IV. PNS = $\frac{241}{621}$ = .388

Assumptions:

		Source
Slow FC Speed:	3.56 ft/sec	FC speed distribution assumed to be similar
Ave FC Speed:	8.53 ft/sec	to T1–T3 at Lower Galice. Assumption checked
Fast FC Speed:	11.9 ft/sec	in field with float through in canoe.
MTB Speed:	40.3 ft/sec	Assumed similar to speeds in Lower Galice T1–T3.
Other:		



Rogue River Boating Safety and Conflicts Study
SOC Analysis

MIDDLETONS
High Flow Range

Prepared by: WRC-Environmental
Sacramento, CA

Downstream MTB Operation

Approach visibility: Although point **A** is visible from points farther upstream it is only continuously visible from point **B** about 425 ft. above the RIP at **C**. At 27.4 mph, there is 10.5 sec. of MTB run time from **B** to **C**. FC would have to float the 54 ft. from **A** to LOS **D** in 10.5 sec (5.1 ft/sec.) or faster to make **B** a more critical visual location than **C**. FC speeds indicate about 3% of the FC are slower than 5.1 ft/sec; typical FC speeds indicate the critical SOC visibility is from the RIP at **C** along LOS **D**.

RIP: The RIP is set 195 ft. above stopping point **E** to accommodate reaction time, and PSD in a 'narrow' set-down. MTBs can drift through the tongue at **F** or set-down in the area of **A** and drift to the ST at **G**. The RIP sets the origin of LOS **D**. At **C** the ST area can be seen along LOS **H** and **I**, however, point **C** is a critical location for observation of the SOC along LOS **D**.

ST: The ST is set at a location where the presence of MTB drifting depths were assumed to be wide enough to allow a safe off-plane MTB/multi-FC pass with adequate craft separation.

PNS: From the RIP to the ST 38.8% of the SOC is below LOS **D**. Based on FC route distribution the PNS is 0.388.

PSR: Safety risk is a result of a through-run condition:

Through-run; FC are between LOS **D** and the ST at **G** when the MTB passes the RIP: During the MTB run the SOC through to the ST becomes visible at **J** and the MTB can set-down to drift by point **K**; 105 ft. below **J** to accommodate reaction time and PSD to drifting. The MTB operating time to the ST is 8.8 sec. over the 356 ft. to point **K** on-plane, and 20.8 sec. over the 265 ft. to the ST at 1.5 times the average FC speed; a total of 29.6 sec. FC must float 241 ft. from LOS **D** to the ST in 29.6 sec to avoid being overtaken. FC speed distribution indicates randomly located FC at the moment the MTB passes the RIP 93.6% will float to the ST in time: The PSR is 0.064.

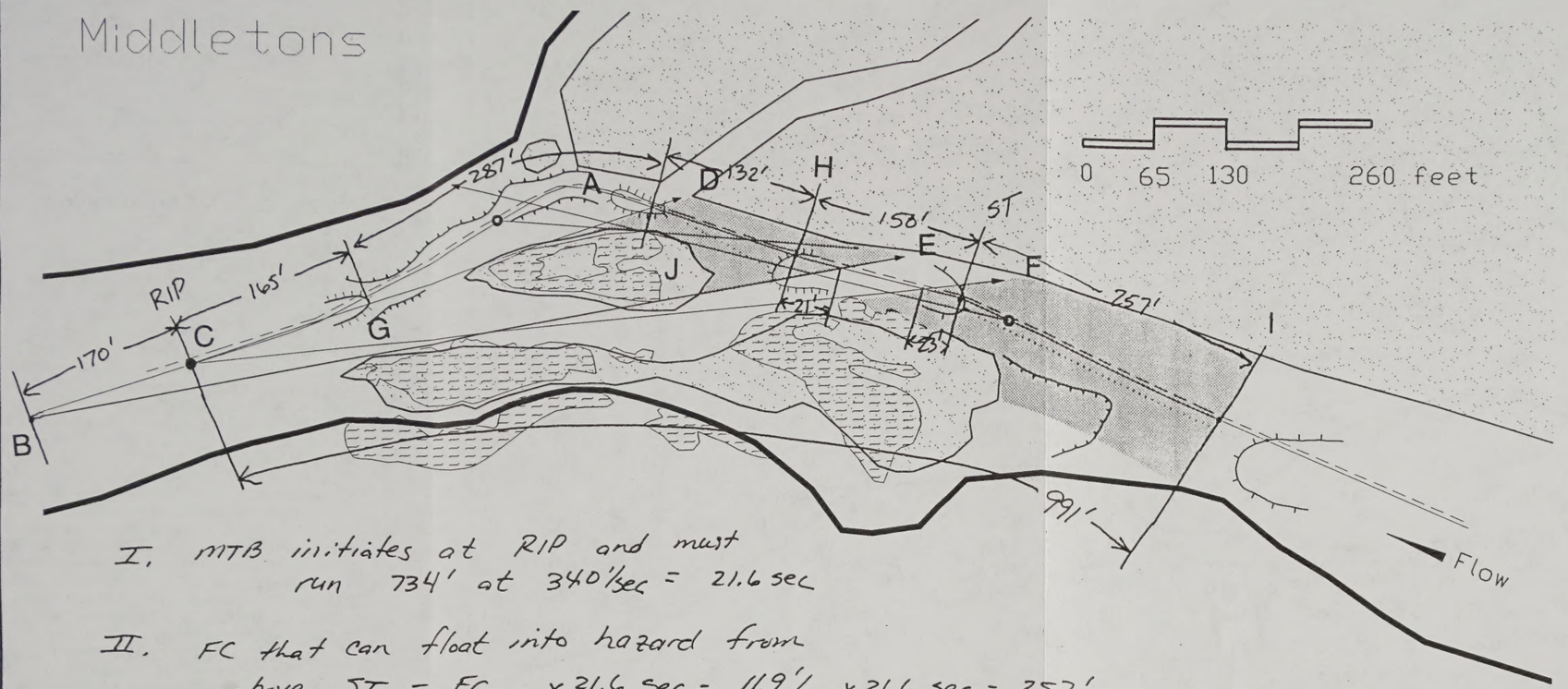
The total PSR is 0.064

Notes:

Vegetation management over the island at **I** could reduce the PNS to zero and the PSR to zero.

FC speed distribution estimates are taken from other SOCs; deviations in actual Middleton FC speed could alter PSR results.

About 25% of observed driftboats had delayed transits, spending from 15 to 30 minutes just above **G** fishing the tailwater and shoal areas. This would be a non-time dependent pop-out safety risk element and would increase the PSR.



I. MTB initiates at RIP and must run 734' at 34.0'/sec = 21.6 sec

II. FC that can float into hazard from above ST = FC_{fast} x 21.6 sec = 11.9'/sec x 21.6 sec = 257'

III PSR = (Risk below ST) + (Risk above ST)

Risk below ST = 100% x proportion of shadow zone = $100\% \times \frac{(21+132+73)}{433} = \frac{176}{433} = .406$

Risk above ST = $\frac{FCave}{FCfast}$ x proportion of shadow zone = $\frac{8.53}{11.9} \times \frac{257}{433} = (.717) \times (.594) = .426$

$PSR_{TOTAL} = .406 + .426 = .832$

IV $PNS = \frac{433}{991} = .437$

Rogue River Boating Safety and Conflicts Study
SOC Analysis

MIDDLETONS
Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA

Upstream MTB Operation

Approach visibility: Although the bottom of the SOC to about point **A** is visible for about 3200 ft. (1:12 min:sec. at 30 mph), the critical SOC visibility is between point **B** and the RIP at **C** along LOS **D**, **E**, and **F**.

RIP: The RIP is set 165 ft. below the set-down threshold at **G** to accommodate reaction time and PSD. MTBs can not stop to avoid in-floating FC until past **H**.

ST: The ST is set by a SSD of 150 ft. above the set-down threshold at **H** to accommodate PSD plus craft separation.

PNS: Based on FC route separation, of the SOC from the RIP to the ST and including a reach above the ST to point **I**, in which FC could float to the ST during MTB run times, 43.7% is not visible from the RIP: PNS is 0.437.

PSR: Safety risk is a combination of through-run and float-in situations:

Through-run; FC are between LOS **D** and **E** or between LOS **F** and the ST at the time the MTB passes the RIP: All FC in this area will be at risk regardless of FC speed. The area between LOS **D** and **E** and between LOS **F** and the ST is 176 ft or 40.6% of the unseen portion of the SOC: The weighted risk for this situation is 0.406.

Float-in; FC are located between the ST and point **I** when the MTB passes the RIP: The MTB run time from the RIP to the ST is 21.6 sec at 23 mph. In 21.6 sec. the fastest FC (11.9 ft/sec.) can float 257 ft.; from point **I** to the ST. Upstream of **I** no FC can float to the ST during the MTB run. FC speed distribution indicates that of the FC randomly located between **I** and the ST at the time the MTB passes **C**, 71.1% can float past the ST. This area is 59.4% of the unseen portion of the SOC: The weighted PSR for this area is 0.426.

The total PSR is (0.406)+(0.426)=0.832

Notes:

Vegetation management over the island at J could reduce the PNS and the PSR to about 0.450 by eliminating those risks below LOS **F**.

FC speed distribution estimates are taken from other SOCs; deviations in actual Middleton FC speed could alter PSR results.

Assumptions:

		Source
Slow FC Speed:	3.56 ft/sec	FC speed distribution assumed to be similar
Ave FC Speed:	8.53 ft/sec	to T1–T3 at Lower Golice. Assumption checked
Fast FC Speed:	11.9 ft/sec	in field with float through in canoe.
MTB Speed:	34.0 ft/sec	Assumed similar to speeds in Lower Golice T1–T3.
Other:		

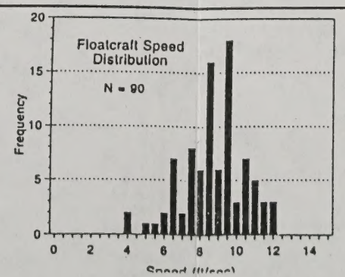
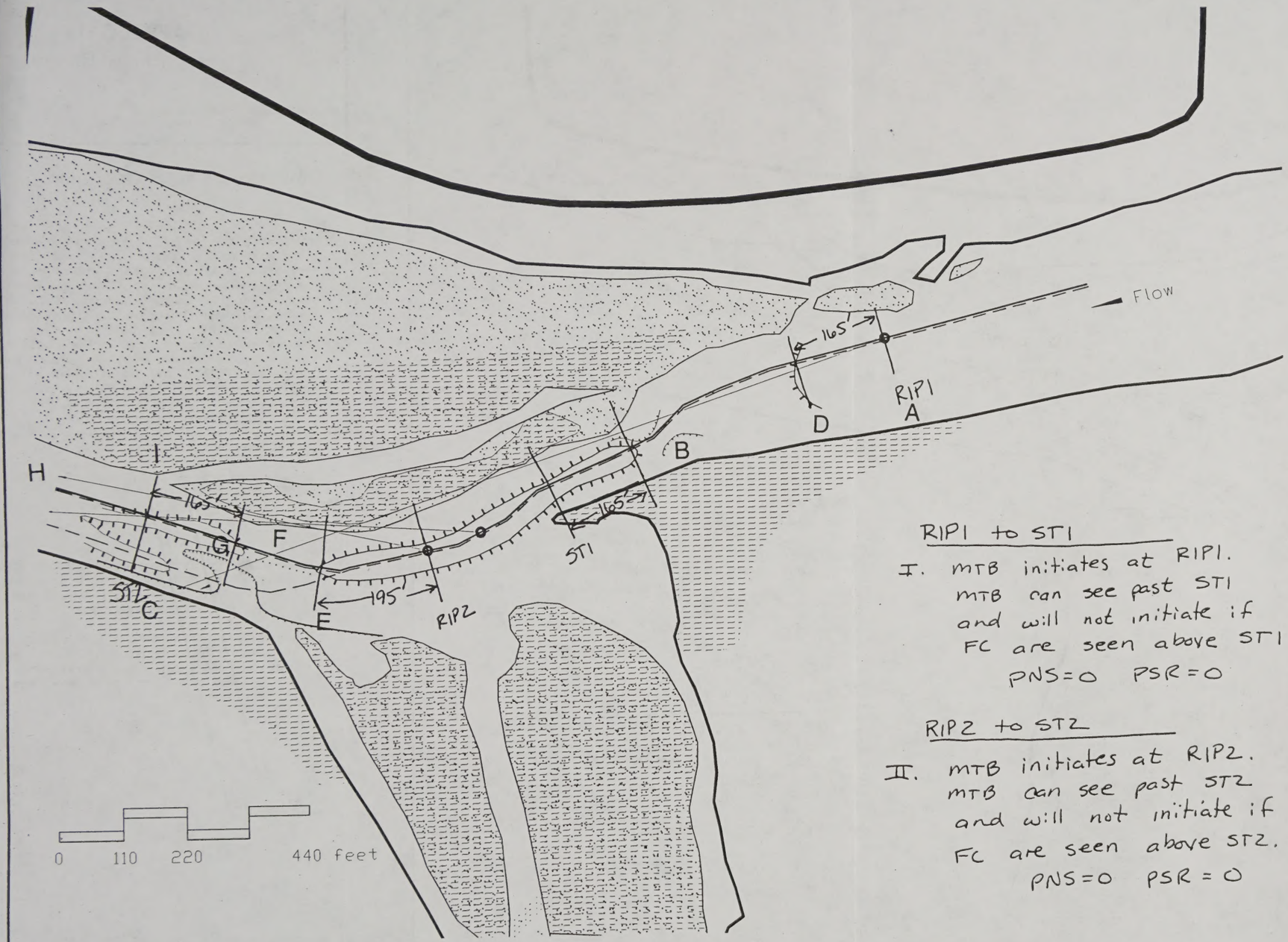


Plate 4

Rogue River Boating Safety and Conflicts Study
SOC Analysis

APPLEGATE
Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA



RIP1 to STI

I. MTB initiates at RIP1.
MTB can see past STI
and will not initiate if
FC are seen above STI
PNS=0 PSR=0

RIP2 to ST2

II. MTB initiates at RIP2.
MTB can see past ST2
and will not initiate if
FC are seen above ST2.
PNS=0 PSR=0

Downstream MTB Operation

Approach visibility: The RIP1 at **A** and point **B** are continuously visible from about 2490 ft. upstream of RIP1; about 55.9 and 65.5 sec. respectively at 30 mph. Point **C** is visible from the RIP1; run time from **A** to LOS **C** is about 29.9 sec. at 30 mph. FC must float from **B** past **C**, 840 ft., in 55.9 sec. (15 ft/sec.) to make approach visibility more critical; typical FC speeds indicate the critical SOC visibility is from RIP1. Visibility from RIP1 is along LOS **C**.

RIP: There are two stopping points: RIP1 is set 165 ft. above stopping point **D** to accommodate reaction time, and PSD in a 'wide' set-down; and RIP2 is set 195 ft. above stopping point **E** to accommodate reaction time, and PSD in a 'narrow' set-down. MTBs can not drift through **F** to the tailwater at **G**. RIP1 sets the origin of LOS **C**, and RIP2 sets the origin of LOS **H**.

ST: The ST at **I** is set by a SSD of 165 ft. below the set-down threshold at **G** to accommodate PSD plus craft separation.

PNS: LOS **C** extends from the RIP1 to a point below the intermediate set-down area at **E**, and LOS **H** extends from RIP2 past the ST at **I**; all FC are visible: PNS is zero.

PSR: All FC are visible: PSR is zero.

Notes:

Possible safety risks not accounted for in assessment include PSRs that may be greater than zero below RIP2 if: 1) LOS **H** needs to include all of RR channel area; 2) MTB speeds are greater than 30 MPH; or, 3) "Large" MTBs are lead craft.

Future safety risks are sensitive to: 1) deposition/erosion at set-down threshold **E** that could change RIP2 location; and, 2) the overall geometry of the SOC due to channel changes that could lead to increased channel curvature between **B** and **I**.

Assumptions: Source

Slow FC Speed:
Ave FC Speed:
Fast FC Speed:

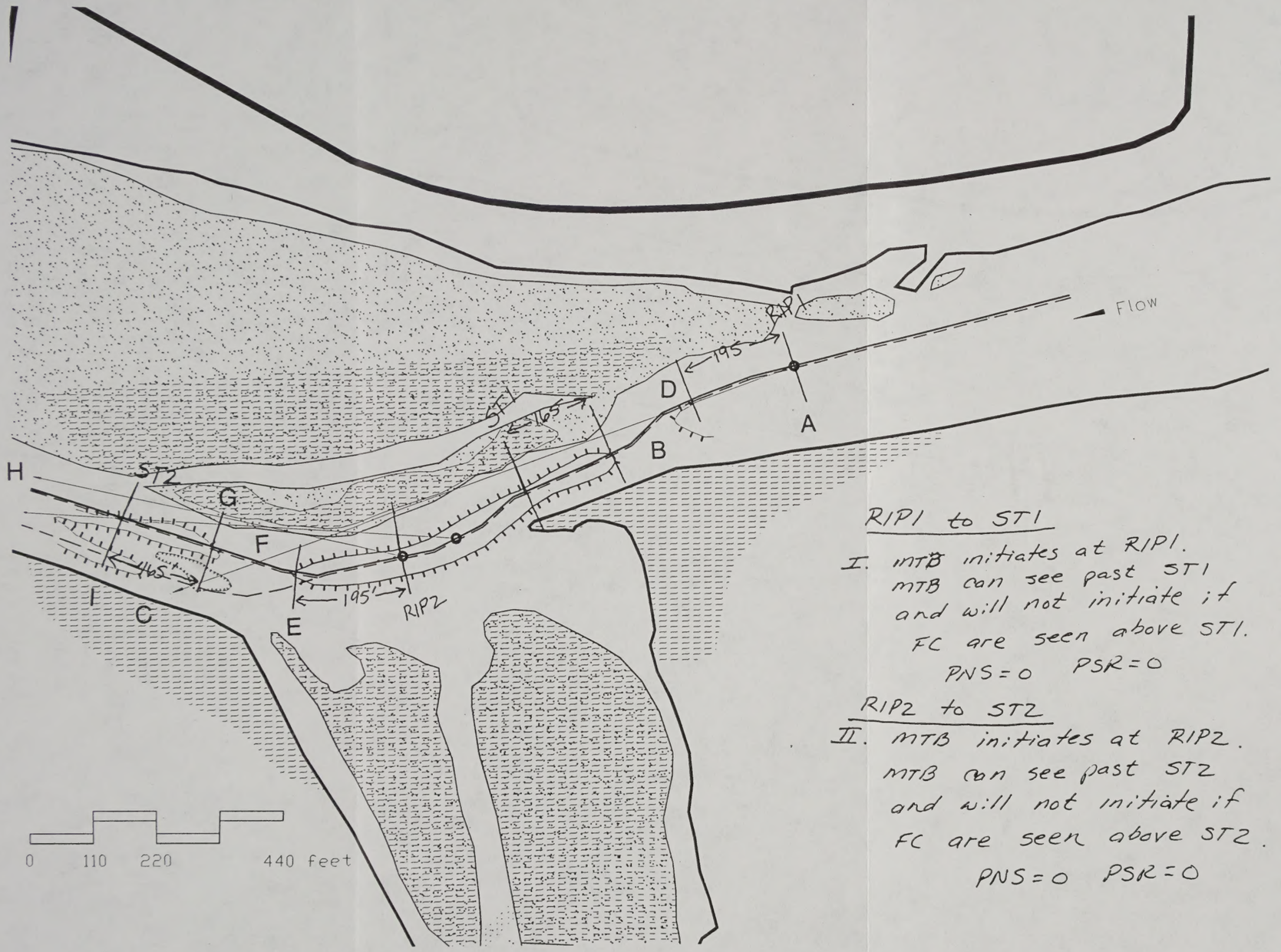
MTB Speed:

Other:

Rogue River Boating Safety and Conflicts Study
SOC Analysis

APPLEGATE
High Flow Range

Prepared by: WRC-Environmental
Sacramento, CA



RIP1 to ST1

I. MTB initiates at RIP1.
MTB can see past ST1
and will not initiate if
FC are seen above ST1.
PNS = 0 PSR = 0

RIP2 to ST2

II. MTB initiates at RIP2.
MTB can see past ST2
and will not initiate if
FC are seen above ST2.
PNS = 0 PSR = 0

Downstream MTB Operation

Approach visibility: The RIP1 at **A** and point **B** are continuously visible from about 2680 ft. upstream of RIP1; about 60.1 and 65.5 sec. respectively at 30 mph. Point **C** is visible from the RIP1; a run time of about 25.3 sec. at 30 mph. FC must float from **B** past **C**, 870 ft., in 60.1 sec. (14.5 ft/sec.) to make approach visibility more critical; typical FC speeds indicate the critical SOC visibility is from RIP1. Visibility from RIP1 is along LOS **C**.

RIP: There are two stopping points: RIP1 is set 195 ft. above stopping point **D** to accommodate reaction time, and PSD in a 'narrow' set-down; and RIP2 is set 195 ft. above stopping point **E** to accommodate reaction time, and PSD in a 'narrow' set-down. MTBs can drift through **F** to the tailwater at **G**. RIP1 sets the origin of LOS **C**, and RIP2 sets the origin of LOS **H**.

ST: The ST at **I** is set by a SSD of 165 ft. below the set-down threshold at **G** to accommodate PSD plus craft separation.

PNS: LOS **C** extends from the RIP1 to a point below the intermediate set-down area at **E**, and LOS **H** extends from RIP2 past the ST at **I**; all FC are visible: PNS is zero.

PSR: All FC are visible: PSR is zero.

Notes:

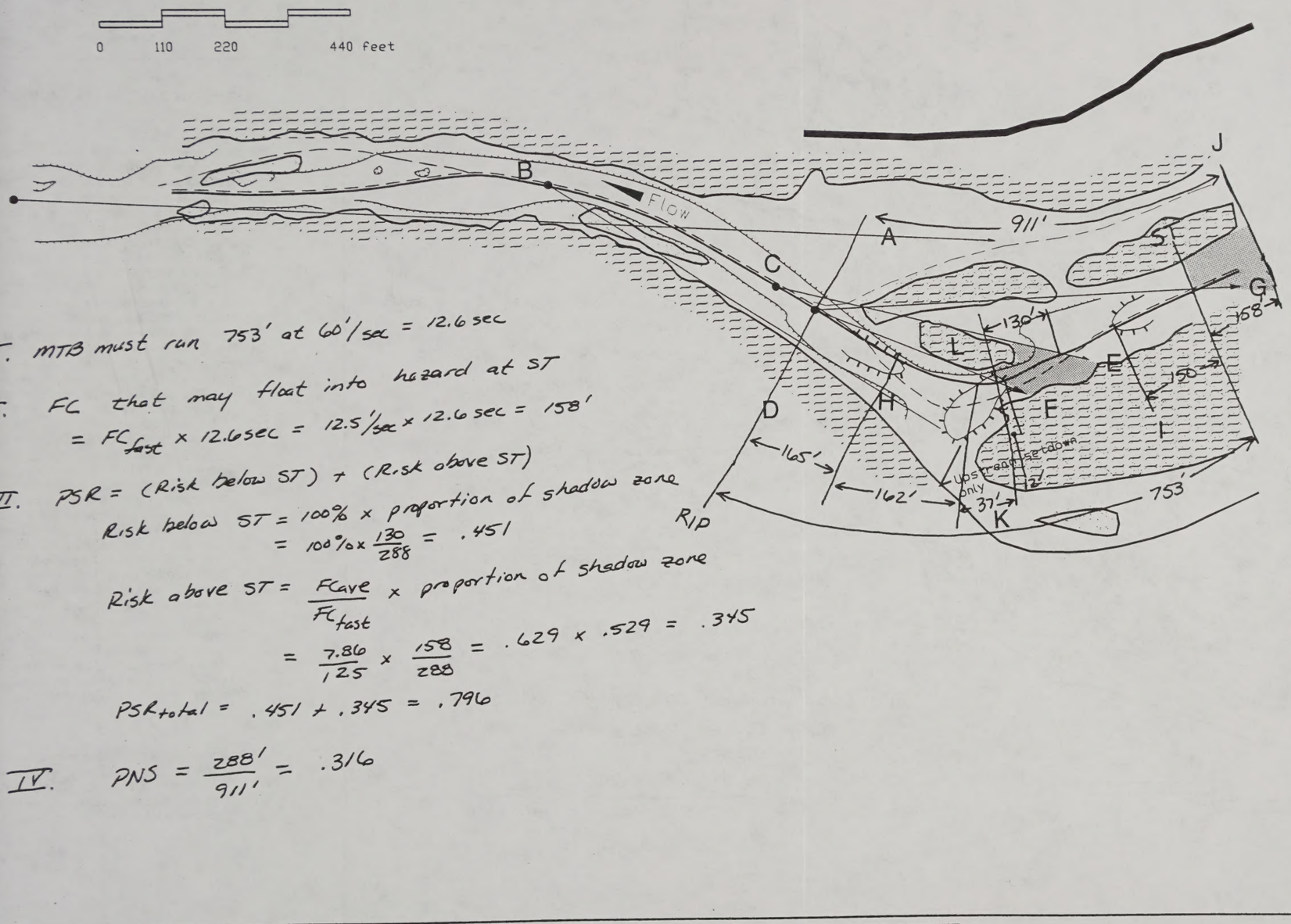
Possible safety risks not accounted for include PSRs that may be greater than zero below RIP2 if: 1) LOS **H** needs to include all of RR channel area; 2) MTB speeds are greater than 30 mph; or, 3) "Large" MTBs are lead craft.

Future safety risks are sensitive to: 1) deposition/erosion at set-down threshold **E** that could change RIP2 location; and, 2) the overall geometry of the SOC due to channel changes that could lead to increased channel curvature between **B** and **I**.

Assumptions: Source

Slow FC Speed:
Ave FC Speed:
Fast FC Speed:

MTB Speed:
Other:



I. MTB must run 753' at 60'/sec = 12.6 sec

II. FC that may float into hazard at ST
= FC_{fast} × 12.6 sec = 12.5'/sec × 12.6 sec = 158'

III. PSR = (Risk below ST) + (Risk above ST)

Risk below ST = 100% × proportion of shadow zone
= 100% × $\frac{130}{288}$ = .451

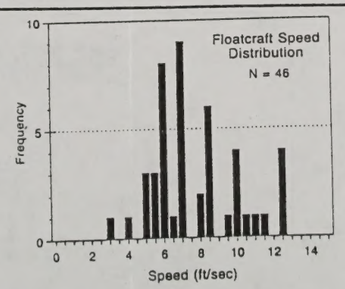
Risk above ST = $\frac{FCave}{FC_{fast}}$ × proportion of shadow zone
= $\frac{7.86}{12.5}$ × $\frac{158}{288}$ = .629 × .529 = .345

PSR_{total} = .451 + .345 = .796

IV. PNS = $\frac{288'}{911'}$ = .316

Assumptions:

		Source
Slow FC Speed:	ft/sec	FC speed distribution assumed to be similar
Ave FC Speed:	7.56 ft/sec	to T1–T2 at Hellgate riffle. Assumption checked
Fast FC Speed:	13.9 ft/sec	at Whitehorse on video with several FC floattimes in T2–T3
MTB Speed:	60.0 ft/sec	Field observations T1–T5
Other:		



Rogue River Boating Safety and Conflicts Study
SOC Analysis

WHITEHORSE

High and Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA

Upstream MTB Operation

Approach visibility: Although the area near the bottom of the SOC is visible for about 1700 ft. (28.3 sec. at 41 mph) along LOS **A**, and the bottom of the SOC is continuously visible from about point **B**, the critical SOC visibility is between point **C** and the RIP at **D** along LOS **E**, **F**, and **G**.

RIP: The RIP is set 165 ft. below the set-down threshold at **H** to accommodate reaction time and PSD.

ST: The ST is set by a SSD of 150 ft. above the set-down threshold at **I** to accommodate PSD plus craft separation.

PNS: Based on FC route separation, of the SOC from the RIP to the ST and including a reach above the ST in which FC could float to the ST during MTB run times, 31.6% is not visible from the RIP: PNS is 0.316.

PSR: Safety risk is a combination of through-run and float-in situations:

Through-run: FC are between LOS **E** and **F** at the time the MTB passes the RIP: All FC in this area will be at risk. The area between LOS **E** and **F** is 45.1% of the unseen portion of the SOC: The weighted PSR for the through-run situation is 0.451.

Float-in: FC are located above LOS **G** when the MTB passes the RIP: The MTB run time to the ST is 12.6 sec at 41 mph. In 12.6 sec. the fastest FC (12.4 ft/sec.) can float 158 ft. This establishes point **J**. Upstream of **J** no FC can float to the ST during the MTB run. FC speed distribution indicates that of the FC randomly located between **J** and the ST at the time the MTB passes the RIP, 62.9% can float past the ST and be involved in a MO. This area is 54.9% of the unseen portion of the SOC: The weighted PSR for the float-in situation is 0.345.

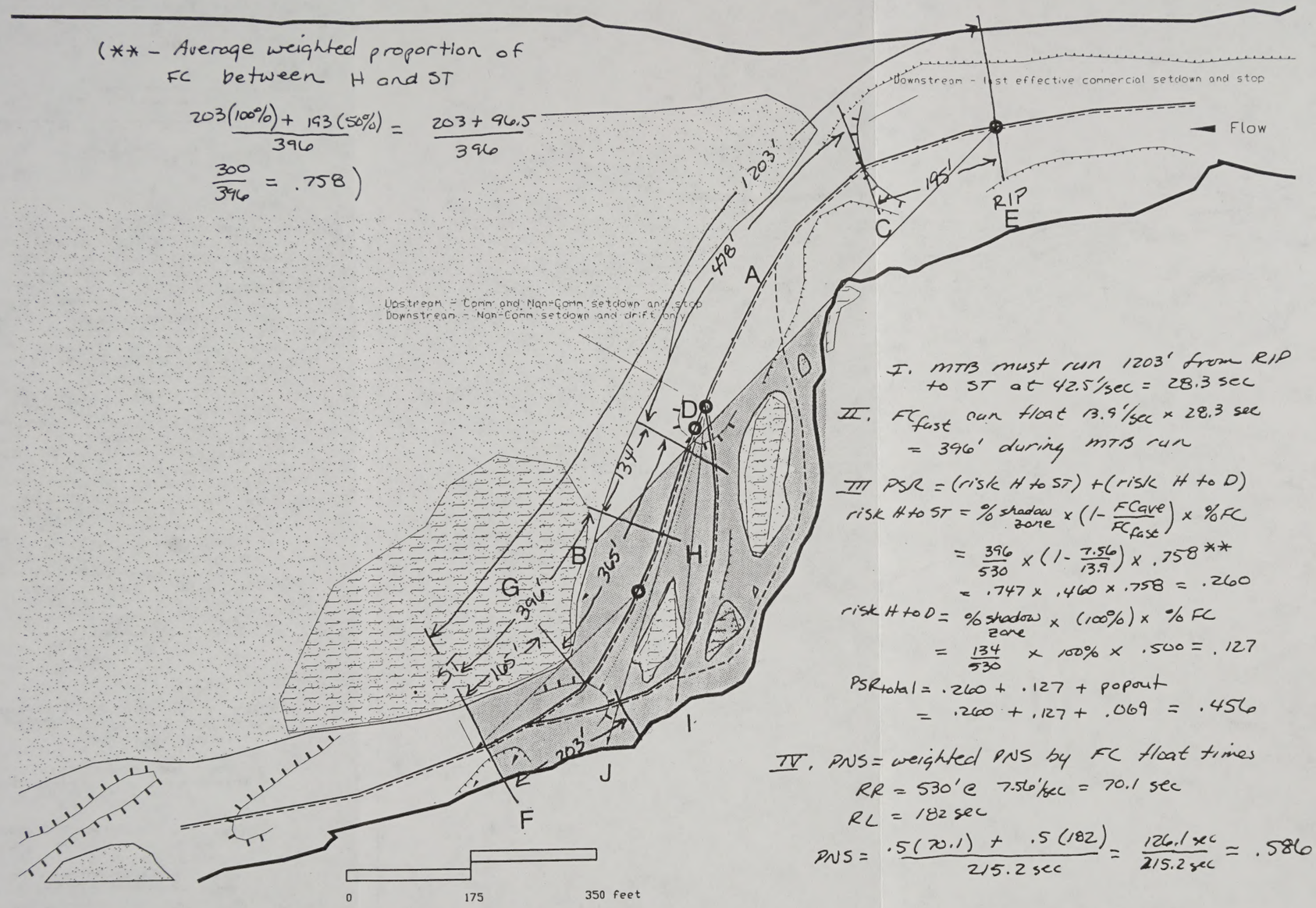
The total PSR is (0.451)+(0.345)=0.796

Notes:

Possible safety risks not observed in 1992 season include pop-outs from RL channel at **K** although LOS and FC speeds indicate that this risk is near zero.

Possible safety risks not part of this assessment includes off-plane MTBs not being able to pass multiple FC safely between **B** and **D**.

Future safety risks are sensitive to: 1) deposition/erosion in RIP and ST areas that could change RIP/ST locations; 2) vegetation condition on islands at **L** and **M** that could change LOS positions; 3) the overall geometry of the SOC due to channel changes; and, 4) increased FC uses of RR channel decreasing the FC uses of the main, center channel. Probably one of the most unstable and changeable SOC areas.



I. MTB must run 1203' from RIP to ST at 42.5'/sec = 28.3 sec

II. FC_{fast} can float 13.9'/sec x 28.3 sec = 396' during MTB run

III. PSR = (risk H to ST) + (risk H to D)

risk H to ST = % shadow zone x $\left(1 - \frac{FC_{ave}}{FC_{fast}}\right)$ x %FC

$= \frac{396}{530} \times \left(1 - \frac{7.56}{13.9}\right) \times .758$ **

$= .747 \times .460 \times .758 = .260$

risk H to D = % shadow zone x (100%) x %FC

$= \frac{134}{530} \times 100\% \times .500 = .127$

PSR total = .260 + .127 + popout

= .260 + .127 + .069 = .456

IV. PNS = weighted PNS by FC float times

RR = 530' @ 7.56'/sec = 70.1 sec

RL = 182 sec

$PNS = \frac{.5(70.1) + .5(182)}{215.2 \text{ sec}} = \frac{126.1 \text{ sec}}{215.2 \text{ sec}} = .586$

Assumptions:

		Source
Slow FC Speed:	ft/sec	Field observations at T4–T5
Ave FC Speed:	7.56 ft/sec	
Fast FC Speed:	13.9 ft/sec	
MTB Speed:	42.5 ft/sec	Field observations T1–T5
Other:		

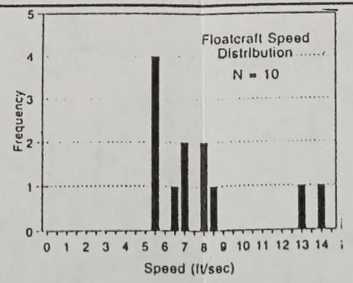


Plate 13

Rogue River Boating Safety and Conflicts Study
SOC Analysis

BRUSHY CHUTES
Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA

Downstream MTB Operation

Approach visibility: Point **A** is continuously visible from about 870 ft. upstream of the RIP; run time of 19.6 sec. to the RIP at 30 mph. Visibility from RIP is along LOS **B**. Typical FC speeds indicate the critical SOC visibility is from RIP.

RIP: The last MTB stopping point is at **C**; they can set-down to **D** but can't stop or get back on-plane, and can't drift to the tailwater at **G**. RIP at **E** is set by a SSD of 195 ft. above **C** to accommodate reaction time, and PSD in a 'narrow' set-down area. The RIP defines the origin of LOS **B**.

ST: The ST at **F** is set by a SSD of 165 ft. below the set-down threshold at **G** to accommodate PSD plus craft separation.

PNS: Based on FC route separation and FC speed variation 58.6% of SOC is not visible from the RIP: PNS is 0.586.

PSR: Safety risk is a combination of through-run and pop-out situations:

Through-run; FC are located between LOS **B** and the ST at the moment the MTB passes the RIP: The MTB run time to the ST is 28.3 sec. at 29 mph. In 28.3 sec. the fastest FC (14.0 ft/sec.) can float 396 ft. from point **H** to the ST. No FC located between LOS **B** and **H** when the MTB passes the RIP is fast enough to float to the ST in time to avoid a MO. This area is 25.3% of the unseen potion of the SOC and 50% of the FC are on the RR route. When weighted for proportion of the area and FC users involved the weighted PSR for this portion of the through-run risk is 0.127. Below point **H** some FC will not reach the ST in time to avoid a MO. FC speed distribution indicates that 46.0% of the FC randomly located between **H** and the ST will not reach it in time to avoid a MO. This area is 74.7% of the unseen portion of the SOC and 75.8% of the FC use this route. When weighted for proportion of the area and FC users involved, the weighted PSR for this portion of the through-run risk is 0.260. The total weighted PSR for the through-run risk is 0.387.

Pop-out; FC spend about 81 sec. between points **I** and **J** and are unseen by approaching MTBs. 50% of the FC cross behind the island and the PSR for this pop-out is 0.069 (See Brushy Chute low flow downstream operation pop-out sheet for details).

Total PSR is (0.387)+(0.069)=0.456.

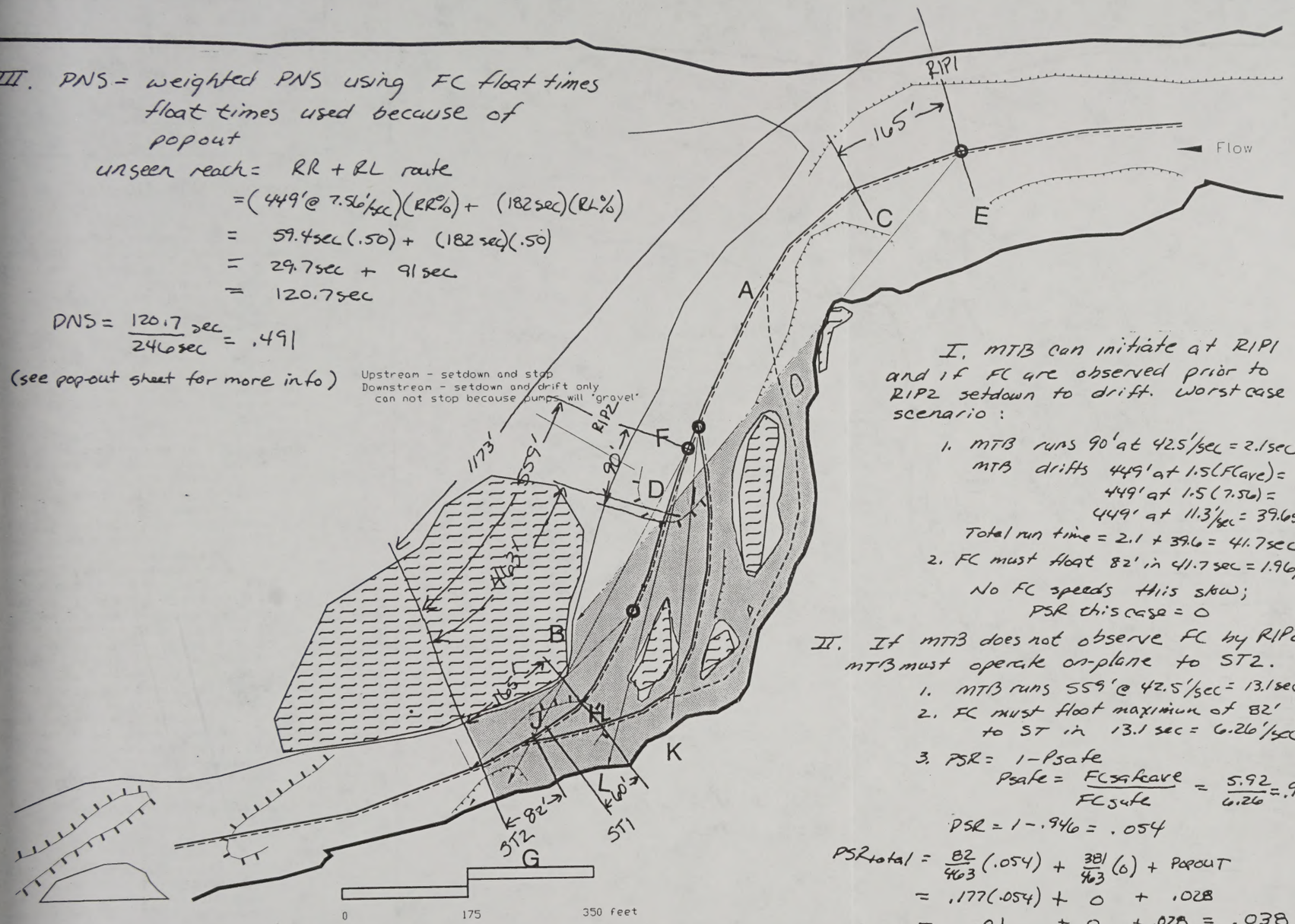
Notes:

Brushy Chute is undergoing progressive channel changes that, on a year to year basis, may result in changing: 1) set-down area sizes and thresholds; channel curvature; and, route patterns. Minor changed in any of these factors could increase or decrease PNS and PSR conditions.

III. PNS = weighted PNS using FC float times
float times used because of
popout
unseen reach = RR + RL route
= (449' @ 7.56'/sec)(RR%) + (182 sec)(RL%)
= 59.4sec (.50) + (182 sec)(.50)
= 29.7sec + 91 sec
= 120.7sec

$PNS = \frac{120.7 \text{ sec}}{246 \text{ sec}} = .491$

(see pop-out sheet for more info)



Upstream - setdown and stop
Downstream - setdown and drift only
can not stop because bumps will 'gravel'

I. MTB can initiate at RIP1 and if FC are observed prior to RIP2 setdown to drift. worst case scenario:

1. MTB runs 90' at 42.5'/sec = 2.1sec
MTB drifts 449' at 1.5(FCave) =
449' at 1.5 (7.56) =
449' at 11.3'/sec = 39.6sec
Total run time = 2.1 + 39.6 = 41.7sec
2. FC must float 82' in 41.7 sec = 1.96'/sec
No FC speeds this slow;
PSR this case = 0

II. If MTB does not observe FC by RIP2 MTB must operate on-plane to ST2.

1. MTB runs 559' @ 42.5'/sec = 13.1sec
2. FC must float maximum of 82' to ST in 13.1 sec = 6.26'/sec
3. PSR = 1 − Psafe

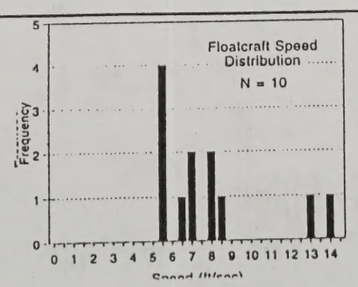
$Psafe = \frac{FC_{safe\,ave}}{FC_{safe}} = \frac{5.92}{6.26} = .946$

PSR = 1 − .946 = .054

$PSR_{total} = \frac{82}{463}(.054) + \frac{381}{463}(0) + PopOut$
= .177(.054) + 0 + .028
= .01 + 0 + .028 = .038

Assumptions:

		Source
Slow FC Speed:	ft/sec	Field observations at T4–T5
Ave FC Speed:	7.56 ft/sec	
Fast FC Speed:	13.9 ft/sec	
MTB Speed:	42.5 ft/sec	Field observations T1–T5
Other:		



Rogue River Boating Safety and Conflicts Study
SOC Analysis

BRUSHY CHUTES
High Flow Range

Prepared by: WRC-Environmental
Sacramento, CA

Downstream MTB Operation

Approach visibility: Point **A** is continuously visible from about 900 ft. upstream of RIP1; a run time of 20 sec. to RIP1 at 30 mph. Visibility from RIP1 is along LOS **B**. Typical FC speeds indicate the critical SOC visibility is from RIP1.

RIP: At high flows the last MTB stopping point is at **C**, a point below which a MTB can't fully stop; they can set-down to **D** but can't stop or get back on-plane; they can drift to the tailwater at **G**. RIP1 at **E** is set by a SSD of 165 ft. above **C** to accommodate reaction time, and PSD to a drifting attitude in a 'narrow' set-down area. The RIP defines the origin of LOS **B**. If the MTB passes RIP1 on-plane a set-down to drift can be initiated to within 110 ft. of **D** (at RIP2, **F**).

ST: The ST at **G** is set by a SSD of 165 ft. below the set-down threshold at **H** to accommodate PSD plus craft separation.

PNS: Based on FC route separation and variable FC speeds 49.1% of SOC is not visible from RIP1: PNS is 0.491.

PSR: Safety risk is a combination of two through-run alternatives and a pop-out situation:

Alternative 1; MTB observes FC in SOC between **I** and **J** from any point between RIP1 and RIP2 and sets-down to drift: The greater length of SOC drifted by the MTBs, the less risk. The worst case is setting-down at RIP2 which is a 41.8 sec. MTB run time from **F** to **G**. 41.8 sec of FC drift time from the LOS threshold at **J** to the ST is a FC speed of 1.96 ft/sec., about 36% of the slowest observed FC speed. The safety risk for Alt 1 is zero. Alt 1 applies to 82.3% of the total unseen area; the weighted PSR for Alt 1 is zero.

Alternative 2; FC are between **J** and ST when the MTB passes RIP2 and can not set-down to drift: The MTB run time from **F** to **G** on-plane is 13.1 sec. FC located at **J** will have 13.1 sec. to float the 82 ft. to the ST, a speed of 6.26 ft/sec. Any FC floating 6.26 ft/sec. or faster will float from **J** past the ST in time to avoid a MO. Based on FC speed distribution 5.4% of all FC randomly distributed in this shadow zone will be overtaken by a MTB. 100% of the FC are using the route in this shadow zone. The safety risk for Alt 2 is 0.054. Alt 2 applies to 17.7% of the unseen area; the weighted PSR for Alt 2 is 0.010.

Pop-out; 50% of all FC use the RC and RL routes and FC spend about 81 sec. between points **K** and **L** unseen by approaching MTBs: the PSR for this pop-out is 0.028 (See Brushy Chute high flow downstream operations pop-out sheet for details).

Total PSR is (0)+(0.010)+(0.028)=0.038.

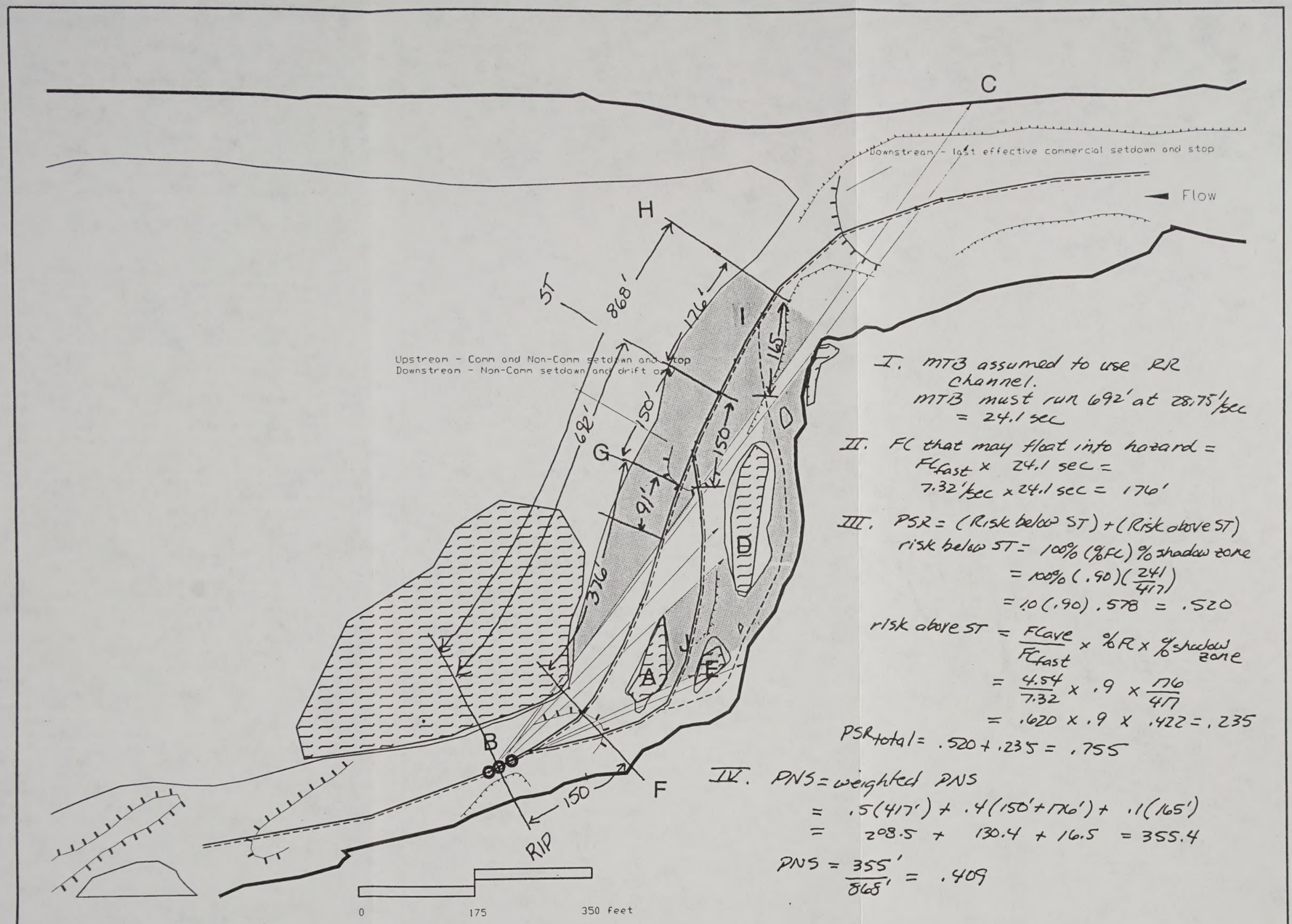
Notes:

Brushy Chute is undergoing progressive channel changes that, on a year to year basis, may result in changing: 1) set-down area sizes and thresholds; channel curvature; and, route patterns. Minor changed in any of these factors could increase or decrease PNS and PSR conditions.

Rogue River Boating Safety and Conflicts Study
SOC Analysis

BRUSHY CHUTES
Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA



I. MTB assumed to use RR channel.
MTB must run 692' at 28.75'/sec
= 24.1 sec

II. FC that may float into hazard =
$FC_{fast} \times 24.1$ sec =
7.32'/sec x 24.1 sec = 176'

III. PSR = (Risk below ST) + (Risk above ST)
risk below ST = 100% (%FC) % shadow zone
= 100% (.90) $(\frac{241}{417})$
= 1.0 (.90) .578 = .520

risk above ST = $\frac{FC_{ave}}{FC_{fast}} \times \%R \times \%_{shadow\ zone}$
= $\frac{4.54}{7.32} \times .9 \times \frac{176}{417}$
= .620 x .9 x .422 = .235

PSR_{total} = .520 + .235 = .755

IV. PNS = weighted PNS
= .5(417') + .4(150'+176') + .1(165')
= 208.5 + 130.4 + 16.5 = 355.4

PNS = $\frac{355'}{868'}$ = .409

Upstream MTB Operation

Approach visibility: Although the RIP and bottom of the SOC to about point **A** are visible from about 1150 ft. (25.8 sec. at 30 mph), below the RIP at **B**, critical SOC visibility is from the RIP. LOS **C**, **D**, and **E** originate from the RIP.

RIP: The RIP is set 165 ft. below the set-down threshold at **F** to accommodate reaction time and PSD. MTBs can not stop to avoid FC until past **G**.

ST: The ST is set by a SSD of 150 ft. above the set-down threshold at **G** to accommodate PSD plus craft separation.

PNS: Based on FC route separation, of the SOC from the RIP to the ST and including a reach above the ST to point **H**, in which FC could float to the ST during MTB run time, 40.9% is not visible from the RIP: PNS is 0.409.

PSR: Safety risk is a combination of through-run and float-in situations:

Through-run; FC are between LOS **C** and the ST on the RR route at the time the MTB passes the RIP: All FC in this area will be at risk regardless of FC speed. 50% of the FC use the area between **G** and LOS **C**, and 90% between **G** and the ST. The area between LOS **C** and the ST (241 ft.) is 57.8% of the unseen portion of the SOC. When weighted for FC use on this RR route (0.90) and risk area length, the PSR for the though-run risk is 0.520.

Float-in; FC are located between the ST and point **H** when the MTB passes the RIP: The MTB run time from the RIP to the ST is 24.1 sec. at 19.6 mph. In 24.1 sec. the fastest FC (7.32 ft/sec.) can float 176 ft.; from **H** to the ST. Upstream of **H** no FC can float to the ST during the MTB run. Between **H** and the ST some FC could float past the ST in time to create a MO. 100% of the FC use the area between **H** and **I**, and 90% between **I** and the ST. When weighted for relative use levels and reach lengths, the weighted percentage of FC potentially involved between **H** and the ST is 90%. FC speed distribution indicates that of the FC randomly located between **H** and the ST at the time of MTB run initiation, 62.0% would float past the ST in time to create a MO. This safety risk area is 42.8% of the unseen portion of the SOC. When weighted for FC use levels (0.90) and risk area length the PSR for the float-in risk is 0.235.

The total PSR is (0.520)+(0.235)=0.755.

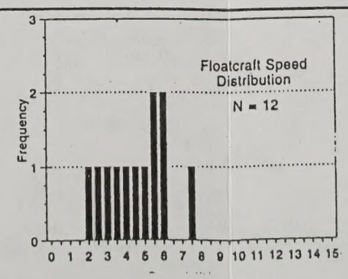
Notes:

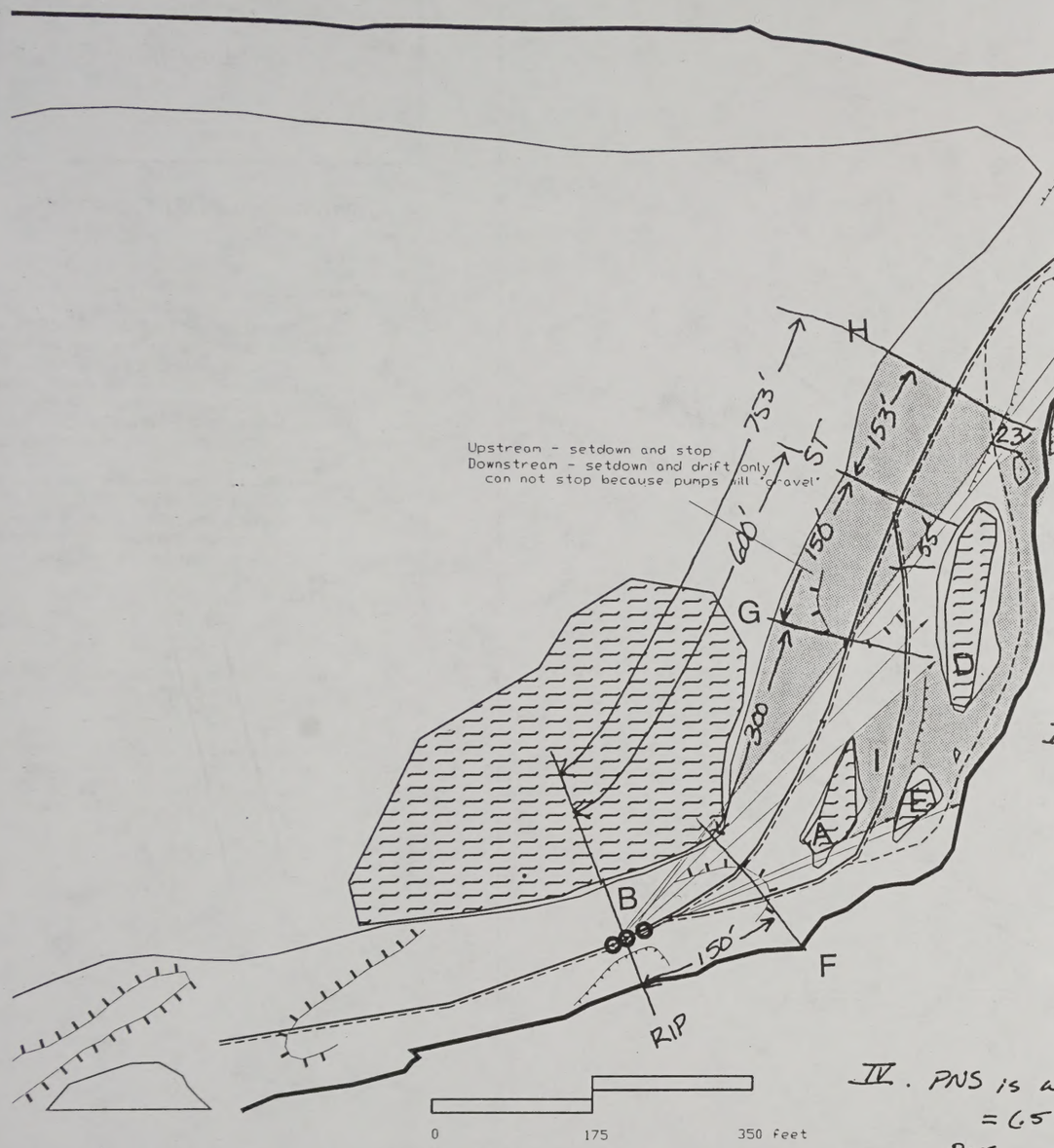
MTB safety risk situations not observed in 1992 that are possible include lead MTB or pvt-JBs using the RC channel in area **J**. Trailing MTBs and single pvt-JBs have been observed using this route. Any MTB/FC encounters in the area of **J** would be a MO. 40% of all FC use this route.

Brushy Chute is undergoing progressive channel changes that, on a year to year basis, may result in changing: 1) set-down area sizes and thresholds; channel curvature; and, route patterns. Minor changed in any of these factors could increase or decrease PNS and PSR conditions.

Assumptions:

		Source
Slow FC Speed:	ft/sec	Field observations at T1-T2
Ave FC Speed:	7.56 ft/sec	
Fast FC Speed:	13.9 ft/sec	
MTB Speed:	28.8 ft/sec	Field observations T1-T5
Other:		





I. Assume MTB uses RR route.
MTB must run 600' at 28.75'/sec
= 20.9 sec

II. FC that may float into hazard at ST = FC_{fast} x 20.9 sec
= 7.32'/sec x 20.9 sec
= 153'
No unseen FC in RL + RC channels can float into risk before MTB proceeds into SOC.

III. PSR = (Risk below ST) + (Risk above ST)
Risk below ST = 100% x % shadow zone
= 100% x $\frac{150}{303}$ = .495
Only 50% of RC use this route
= .5 x .495 = .248

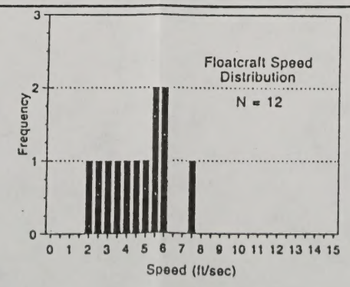
Risk above ST = $\frac{F_{flare}}{F_{fast}}$ x % shadow zone x % FC
= $\frac{45.4}{7.32}$ x $\frac{153}{303}$ x .900
= .620 x .505 x .900 = .282

PSR_{total} = .248 + .282 = .530

IV. PNS is weighted.
= (.5)(303') + .4(153'+55') + .1(23') = 237'
PNS = $\frac{237'}{753'}$ = .315

Assumptions:

		Source
Slow FC Speed:	1.86 ft/sec	Field observations at T1–T2
Ave FC Speed:	4.54 ft/sec	
Fast FC Speed:	7.32 ft/sec	
MTB Speed:	28.8 ft/sec	Field observations T1–T5
Other:		



Rogue River Boating Safety and Conflicts Study
SOC Analysis

BRUSHY CHUTES
High Flow Range

Prepared by: WRC-Environmental
Sacramento, CA

Upstream MTB Operation

Approach visibility: Although the RIP and bottom of the SOC to about point **A** are visible from about 1150 ft. (25.8 sec. at 30 mph), below the RIP at **B**, critical SOC visibility is from the RIP. LOS **C**, **D**, and **E** originate from the RIP.

RIP: The RIP is set 165 ft. below the set-down threshold at **F** to accommodate reaction time and PSD. MTBs can not stop to avoid FC until past **G**.

ST: The ST is set by a SSD of 150 ft. above the set-down threshold at **G** to accommodate PSD plus craft separation.

PNS: Based on FC route separation, of the SOC from the RIP to the ST and including a reach above the ST to point **H**, in which FC could float to the ST during MTB run time, 31.5% is not visible from the RIP: PNS is 0.315.

PSR: Safety risk is a combination of through-run and float-in situations:

Through-run; FC are between LOS **C** and the ST on the RR route at the time the MTB passes the RIP: All FC in this area will be at risk regardless of FC speed. 50% of the FC use this area. The area between LOS **C** and the ST (150 ft.) is 49.5% of the unseen portion of the SOC. When weighted for FC use levels (0.50) and risk area length, the PSR for the though-run risk is 0.248.

Float-in; FC are located between the ST and point **H** when the MTB passes the RIP: The MTB run time from the RIP to the ST is 20.9 sec. at 19.6 mph. In 20.9 sec. the fastest FC (7.32 ft/sec.) can float 153 ft.; from **H** to the ST. Upstream of **H** no FC can float to the ST during the MTB run. Between **H** and the ST some FC could float past the ST in time to create a MO. 90% of the FC use this area. FC speed distribution indicates that of the FC randomly located between **H** and the ST at the time of MTB run initiation, 62.0% would float past the ST in time to create a MO. This safety risk area is 50.5% of the unseen portion of the SOC. When weighted for FC use levels (0.90) and risk area length, the PSR for the float-in risk is 0.282.

The total PSR is (0.248)+(0.282)=0.530.

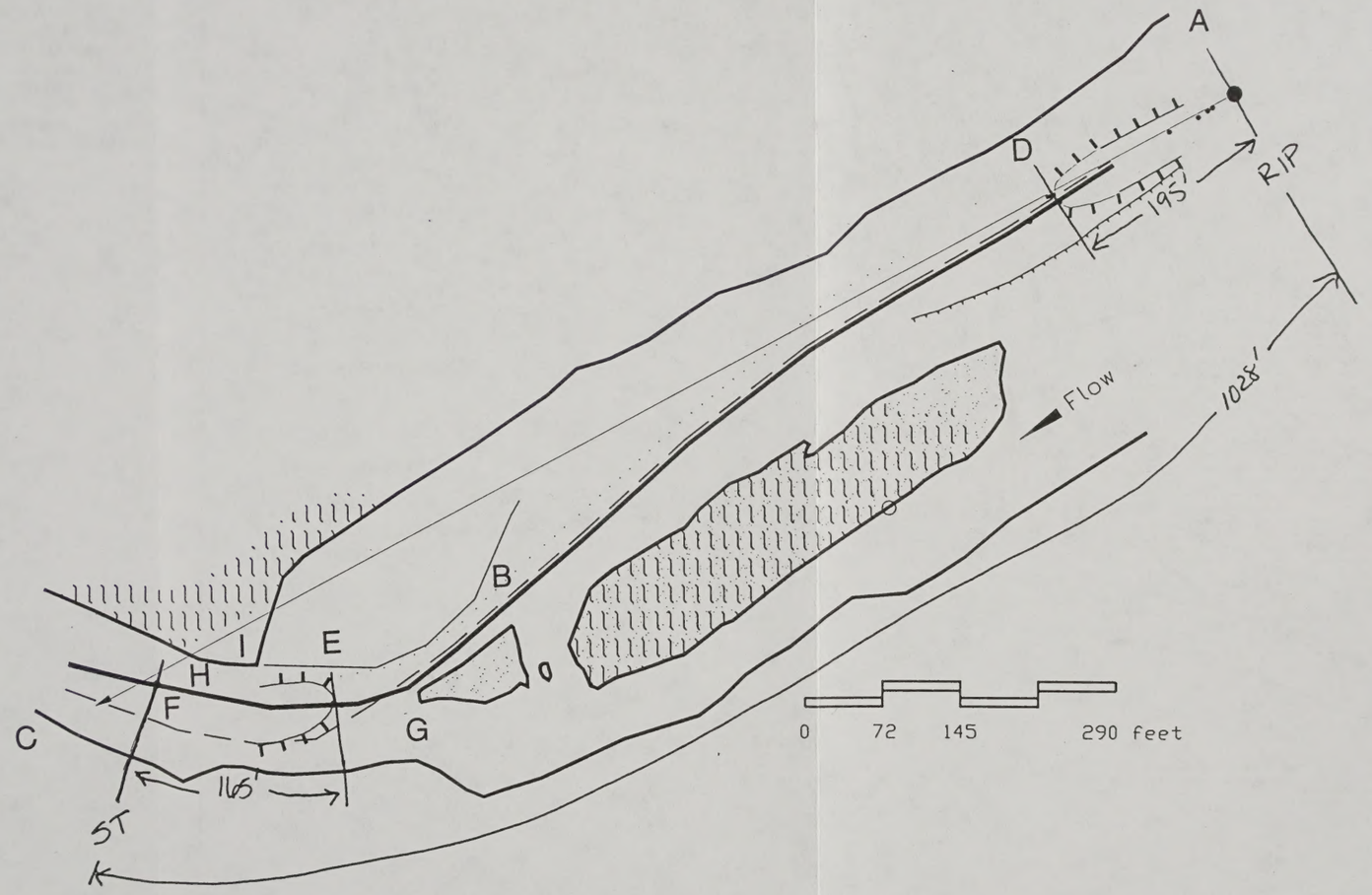
Notes:

MTB safety risk situations not observed in 1992 that are possible include lead MTB or pvt. JB using the RC channel in area **I**. Trailing MTBs and single pvt. JBs have been observed using this route. Any MTB/FC encounters in the area of **I** would be a MO. 40% of all FC use this route.

Brushy Chute is undergoing progressive channel changes that, on a year to year basis, may result in changing: 1) set-down area sizes and thresholds; channel curvature; and, route patterns. Minor changed in any of these factors could increase or decrease PNS and PSR conditions.

Plate 18

I. MTB can see past ST from RIP
PSR = 0
PNS = 0



Assumptions:

Source

Slow FC Speed:
Ave FC Speed:
Fast FC Speed:

MTB Speed:

Other:

Plate 19

Rogue River Boating Safety and Conflicts Study
SOC Analysis

TWO BIT
Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA

Downstream MTB Operation

Approach visibility: The RIP at **A** and point **B**, a partial horizon line, are continuously visible from about 1600 ft. upstream of the RIP; run times of about 36 and 54.4 sec. respectively at 30 mph. Point C is visible from the RIP; a run time from the RIP about 27.7 sec. at 30 mph. FC must float from **B** past **C**, 430 ft., in 36 sec. (11.9 ft/sec.) to make approach visibility more critical; typical FC speeds indicate the critical SOC visibility should be considered as from the RIP. Visibility from the RIP is along LOS **C**.

RIP: The last MTB stopping point is at **D**; they can not drift to tailwater at **E**. The RIP at **A** is set by a SSD of 195 ft. above **D** to accommodate reaction time, and PSD in a 'narrow' set-down area. The RIP defines the origin of LOS **C**.

ST: The ST at **F** is set by a SSD of 165 ft. below the set-down threshold at **E** to accommodate PSD plus craft separation.

PNS: LOS **C** extends from the RIP to a point below ST at **F**, all FC are visible: PNS is zero.

PSR: All FC are visible: PSR is zero.

Notes:

Possible safety risks not observed in 1992 season include: 1) pop-outs from RL channel at **G**; and, 2) pop-outs from below point-bar at **H**.

Future safety risks are sensitive to: 1) deposition/erosion in RIP area that could change RIP location; 2) vegetation condition on point-bar at **I** that could change LOS position; and, 3) the overall geometry of the SOC due to channel changes.

I. MTB initiates at RIP and must run 1563' to ST. ST defined as first location where channel hydraulics allow MTB to come to complete stop in proximity of FC.
MTB runs 1163' on-plane at 44.5'/sec = 26.1 sec
MTB drifts 400' @ 1.5(FCave) = 400' at 8.69'/sec = 46.0 sec
total run time = 26.1 + 46.0 = 72.1 sec

II. PSR = (risk in R1) + (Risk in R2)
risk in R1 = FC must float max. 990' in 72.1 sec = 13.73'/sec
R fast con float 8.14'/sec x 72.1 sec = 586'
Any FC above 586' above ST is at risk.

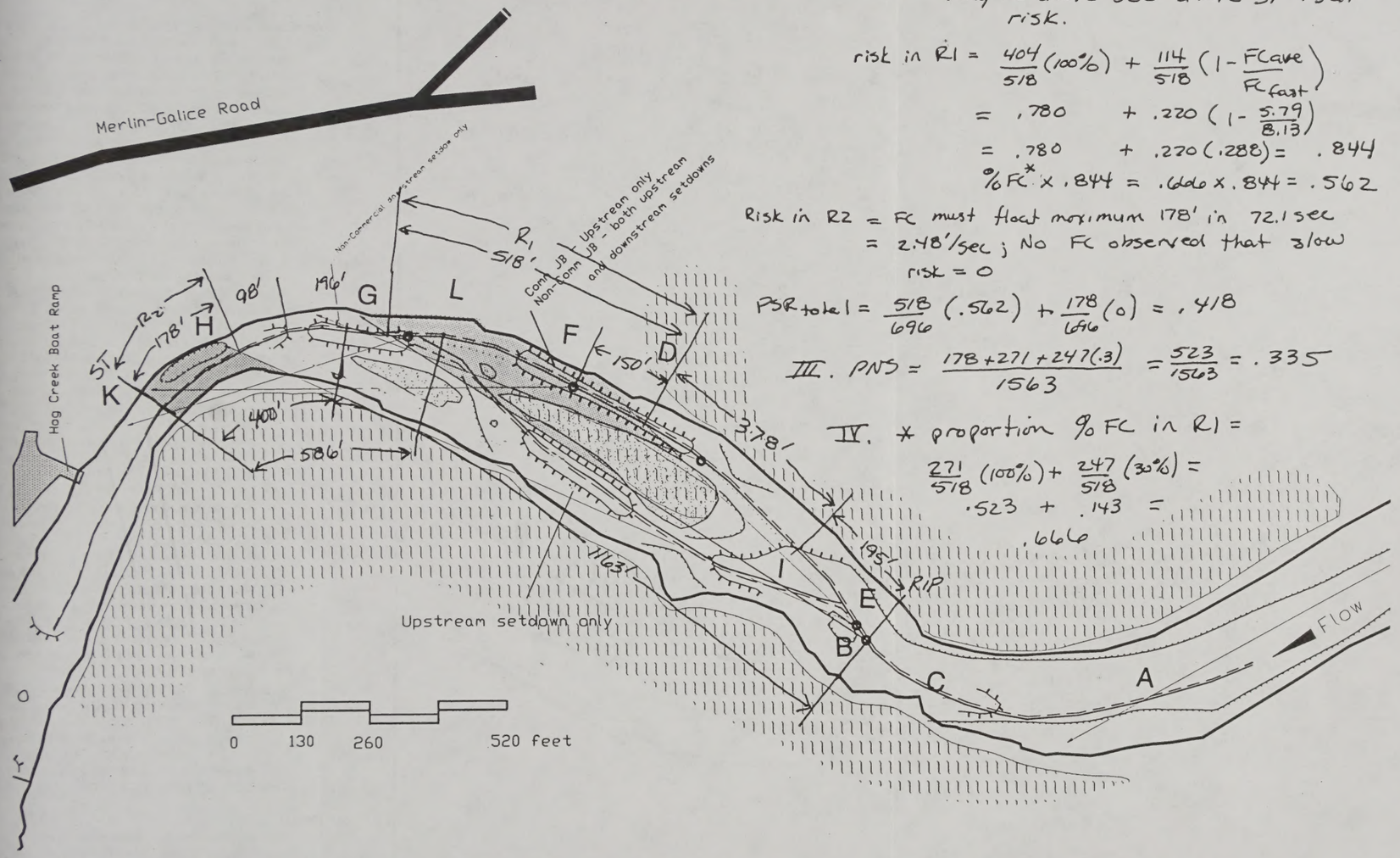
$$\text{risk in R1} = \frac{404}{518}(100\%) + \frac{114}{518}\left(1 - \frac{FC_{ave}}{FC_{fast}}\right)$$
$$= .780 + .220\left(1 - \frac{5.79}{8.13}\right)$$
$$= .780 + .220(.288) = .844$$
$$\%FC^{*} \times .844 = .666 \times .844 = .562$$

Risk in R2 = FC must float maximum 178' in 72.1 sec
= 2.48'/sec; No FC observed that slow
risk = 0

$$PSR_{total} = \frac{518}{696}(.562) + \frac{178}{696}(0) = .418$$

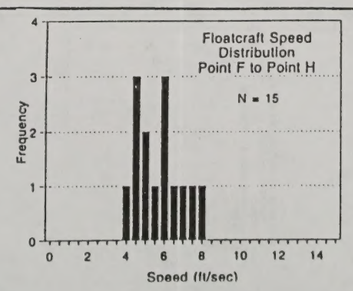
III. $PNS = \frac{178 + 271 + 247(.3)}{1563} = \frac{523}{1563} = .335$

IV. * proportion % FC in R1 =
$\frac{271}{518}(100\%) + \frac{247}{518}(30\%) =$
.523 + .143 =
.666



Assumptions:

		Source
Slow FC Speed:	3.56 ft/sec	Field observations at T3–T6
Ave FC Speed:	5.79 ft/sec	
Fast FC Speed:	8.13 ft/sec	
MTB Speed:	44.5 ft/sec	Field observations at T1–T6
Other:		



Rogue River Boating Safety and Conflicts Study
SOC Analysis

HOG CREEK ISLANDS
Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA

Downstream MTB Operation

Approach visibility: Point **A** is continuously visible from about 3900 ft. upstream. With a 1.5-3 min. MTB interpretation stop at Jumpoff Joe Creek, the visibility time to **A** is 2.5-4 min. At 30 mph, a straight run visibility time to **A** would be 1:27.8 min:sec. At 30 mph, MTB run time from point **A** to the RIP is about 13 sec.; during driftboat season MTBs occasionally stop at **C** for about 30 sec. FC speed distribution in the upper end of the SOC shows that from **A**, fast FC reach the area of **D** and slow FC reach the area of **E** in 2.5-4 min. Typical FC speeds indicate the critical SOC visibility is from the RIP at **B** along the three LOS **F**, **G**, and **H**.

RIP: The last MTB stopping point is at **I**; they can physically set-down in several areas but can't stop or get back on-plane; they can set-down to drift at **J**, 105 ft. below the set-down threshold to accommodate PSD to drift. The RIP at **B** is set by a SSD of 195 ft. above **I** to accommodate best LOS position, reaction time, and PSD in a 'narrow' set-down area.

ST: The ST at **K** is set by channel widening that may allow for adequate MTB maneuvering past FC even though MTBs are drifting at **J**.

PNS: Based on FC route separation 33.5% of SOC is not visible from the RIP: PNS is 0.335.

PSR: Safety risk is a combination of two through-run alternatives:

Alternative 1; MTB passes the RIP and FC are between LOS **F** and **G**: The average MTB run time to the ST is 72.1 sec. including on-plane to **J** and drifting to the ST. Based on FC speed distribution, the fastest FC (8.14 ft/sec) must be at **L** to float to the ST before being overtaken by JBs. Between **L** and LOS **F** all FC are at risk of being overtaken, between LOS **G** and **L** a portion of FC will be at risk depending on FC speed and location. Based on FC speed distribution, 84.4% of all FC randomly distributed in this shadow zone will be overtaken by a MTB. This shadow zone is 74.4% of the total unseen areas; the weighted safety risk of Alt 1 is 0.418.

Alternative 2: MTB passes the RIP and FC are between LOS **H** and the ST: Based on the average MTB run time to the ST of 72.1 sec. only FC with speeds less that 2.48 ft./sec. can not float from **H** to the ST in time to avoid a MO. The slowest observed FC was 5.4 ft./sec.: The safety risk for Alt 2 is zero.

Total PSR is (0.418)+(0)=0.418.

Notes:

- The islands and split channels of this SOC result from a balance of gravel sediment load and stream power enforced by streamflow regime and the bedrock bank at **D** through **K**. Changes in bedload and streamflow regime could lead to changes in the channel characteristics including: 1) changing set-down areas; 2) changing balance in flow between channels; 3) changing island configuration and LOS. All of these could increase or decrease PNS and PSRs year to year.

Plate 23

I. MTB must operate on-plane from RIP to ST = 1057' at 39.4'/sec = 26.8 sec

II. RIP is set at 165' below C. C is the last place to setdown and stop in controlled manner safe for both FC and MTB due to strong current/ hydraulics that force craft to the outside of channel.

III. FC that may float into risk = FC_{fast} x 23.0 sec
= 8.14'/sec x 23.0 sec = 187'

III. PSR = (Risk below K/G) + (risk K to J + G to I)
+ (risk above J/I)

risk below K/G = 100% of FC x % shadow zone
= 100% x $\frac{457}{644}$ = .710

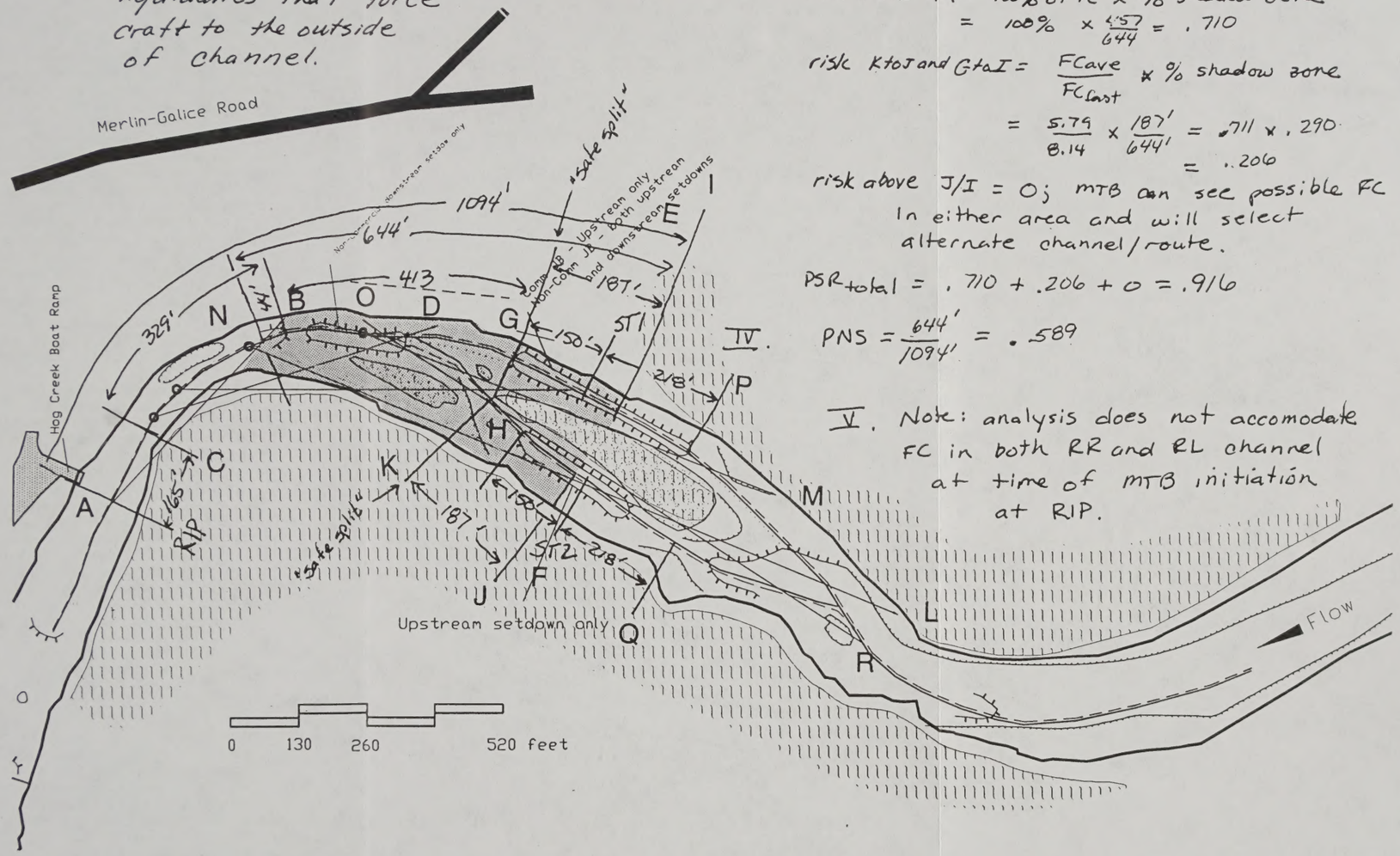
risk K to J and G to I = $\frac{FC_{ave}}{FC_{fast}}$ x % shadow zone
= $\frac{5.79}{8.14}$ x $\frac{187'}{644'}$ = .711 x .290
= .206

risk above J/I = 0; MTB can see possible FC in either area and will select alternate channel/route.

PSR_{total} = .710 + .206 + 0 = .916

IV. PNS = $\frac{644'}{1094'}$ = .589

V. Note: analysis does not accomodate FC in both RR and RL channel at time of MTB initiation at RIP.



Assumptions:

		Source
Slow FC Speed:	3.56 ft/sec	Field observations at T3-T6
Ave FC Speed:	5.79 ft/sec	
Fast FC Speed:	8.13 ft/sec	
MTB Speed:	39.4 ft/sec	Field observations at T1-T6
Other:		

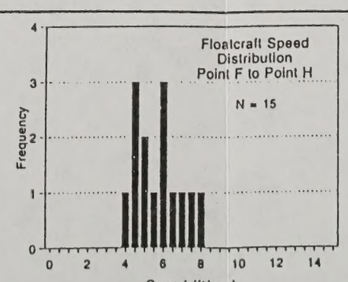


Plate 25

Rogue River Boating Safety and Conflicts Study
SOC Analysis

HOG CREEK ISLANDS
Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA

Upstream MTB Operation

Approach visibility: Although the bottom of the SOC is visible for about 1000 ft. (run time of 25.4 sec. at 27 mph) the critical SOC visibility is from the RIP at **A**. Visibility from RIP is along LOS **B**.

RIP: The RIP is set 165 ft. below a narrow point in the channel at **C** that is assumed to be the last safe place to set-down, back a MTB downstream, or let FC pass even though the set-down threshold is located at **D**. Off-plane MTB/FC encounters between **C** and **D** are considered MOs due to turbulence, narrowness, and bedrock shoals. The 165 ft. accommodates reaction time and PSD.

ST: The ST1 in the RR channel at **E** and ST2 in the RL channel at **F** are set by SSDs of 150 ft. above the set-down thresholds at **G** and **H** to accommodate PSD plus craft separation.

PNS: It is assumed that stopped MTBs can safely let FC pass in the set-down areas of ST1 and ST2 due to width and turbulence factors. Based on observed FC speed distribution and risk alternatives MOs with FC located above points **I** and **J** can be avoided (see and below); this sets the upstream limit of the SOC. Based on FC route separation distribution, 58.9% of the FC route in the SOC is not visible from the RIP: PNS is 0.589.

PSR: Safety risk is a combination of three through-run alternatives:

Alternative 1; After passing the RIP, FC are encountered between the "safe split" line at **K** and LOS **B**: Below the safe split points, FC in either channel would be involved in a MO regardless of the channel taken by the MTB. This would involve 100% of the FC. There are two elements to this alternative: 1) All FC located between **K** and **B** at the time of MTB RIP departure would be involved in an MO. The FC route in this reach is 71% of the unseen routes: the weighted PSR for this part of Alt 1 is 0.710. 2) FC in one channel could float past **K** during the MTB run time from the RIP to **K** (23 sec. at 27 mph). Observed FC speeds indicate that the fastest FC could reach **K** from 187 ft. in 23 sec. so above **I** and **J** no FC are at risk. FC speed distribution indicates that 71.1 % of the FC randomly located from **I** and **J** to **K** could pass **K** in 23 sec. The FC route length in these reaches are 29% of the unseen routes; the weighted PSR for this part of Alt 1 is 0.206. The total weighted PSR for Alt 1 is 0.916.

Alternative 2; FC is seen in the RL channel along LOS **L** from point **N**. Based on operational rules the MTB would take the RR channel: PSR for Alt. 2 is zero.

Alternative 3; FC is unseen between LOS **L** and **M** when a MTB decides to run the RR channel at point **O**: The MTB run time from **O** to ST1 is about 11.2 sec. at 27 mph. The FC would have to float at a minimum of 24 ft./sec. to transit from LOS **M** to **E** to incur a MO. The fastest FC observed are much slower. No FC would be at risk: PSR for Alt. 3 is zero.

Total PSR is (0.916)+(0)+(0)=0.0.916.

Notes:

Calculated risks do not include both channels occupied by FC. When FC are located both channels slow FC speeds indicate that the PSR is 1.0 if they are within 111 ft. above the STs when the MTB passes the RIP and degrades towards zero if they are located at points **P** and **Q**.

The islands and split channels of this SOC result from a balance of gravel sediment load and stream power enforced by streamflow regime and the bedrock bank at **D** through **K**. Changes in bedload and streamflow regime could lead to changes in the channel characteristics including: 1) changing set-down areas; 2) changing balance in flow between channels; 3) changing island configuration and LOS. All of these could increase or decrease PNS and PSRs year to year.

I. MTB must run from RIP to ST = 1125' at 39.4'/sec = 28.8 sec

II. RIP set at 165' below C. C last safe place to setdown and stop in controlled manner in an area safe for FC and MTB due to strong current / hydraulics.

III. MTB run time to K = 377' at 39.4'/sec = 9.6sec
FC_{fast} in RL channel can float 8.14'/sec x 9.6 = 78'
FC_{fast} in upstream areas of RR and RL channel can float 8.14'/sec x 28.8 sec = 218'

IV. PSR = (risk below G/L) + (risk G to I and L to J) + (risk above I and J)

risk below G/L = (risk RL) + (risk RR)

risk RL = proportion channel $\left(\frac{FC_{ave}}{FC_{fast}}\right)$(%FC)

$= \frac{78}{457}\left(\frac{5.79}{8.14}\right)(.08) = .010 \times$ % shadow zone

$= .010 \times \frac{457}{644} = .007$

risk RR = proportion channel (100%)(%FC)(%shadow zone)

$= \frac{457}{457}(100\%)(.92)\frac{457}{644} = .653$

risk G to I and L to J = $\frac{FC_{ave}}{FC_{fast}} \times \%FC = \frac{5.79}{8.14} \times .92 = .654$

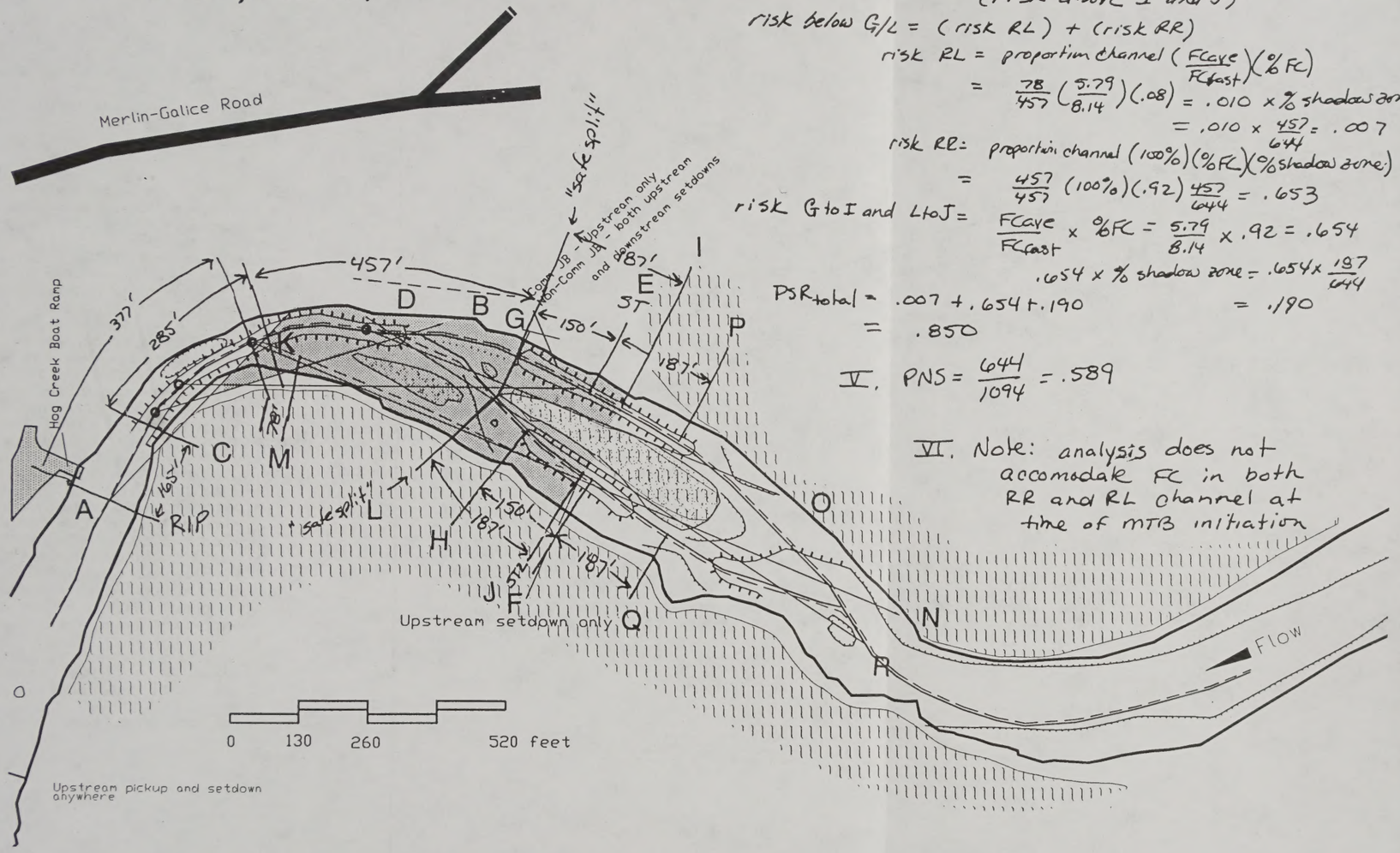
$.654 \times$ % shadow zone $= .654 \times \frac{187}{644}$ $= .190$

$PSR_{total} = .007 + .654 + .190$

$= .850$

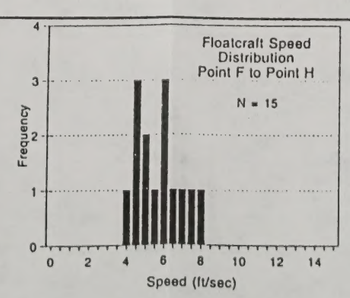
V. $PNS = \frac{644}{1094} = .589$

VI. Note: analysis does not accomodate FC in both RR and RL channel at time of MTB initiation



Assumptions:

		Source
Slow FC Speed:	3.56 ft/sec	Field observations at T3-T6
Ave FC Speed:	5.79 ft/sec	
Fast FC Speed:	8.13 ft/sec	
MTB Speed:	39.4 ft/sec	Field observations at T1-T6
Other:		



Rogue River Boating Safety and Conflicts Study
SOC Analysis

HOG CREEK ISLANDS
High Flow Range

Prepared by: WRC-Environmental
Sacramento, CA

Upstream MTB Operation

Approach visibility: Although the bottom of the SOC is visible for about 1000 ft. (25.4 sec. at 27 mph) the critical SOC visibility is from the RIP at **A**. Visibility from RIP is along LOS **B**.

RIP: The RIP is set 165 ft. below a narrow point in the channel at **C** that is assumed to be the last safe place to set-down, back a MTB downstream, or let FC pass even though the set-down threshold is located at **D**. Off-plane MTB/FC encounters between **C** and **D** are considered MOs due to turbulence, narrowness, and bedrock shoals. The 165 ft. SSD accommodates reaction time and PSD.

ST: The ST1 in the RR channel at **E** and ST2 in the RL channel at **F** are set by SSDs of 150 ft. above the set-down thresholds at **G** and **H** to accommodate PSD plus craft separation.

PNS: It is assumed that stopped MTBs can safely let FC pass in the set-down areas of ST1 and ST2 due to width and turbulence factors. Based on observed FC speed distribution and risk alternatives MOs with FC located above points **I** and **J** can be avoided (see below); this sets the upstream limit of the SOC. Based on FC route separation distribution, 58.9% of the FC route in the SOC is not visible from the RIP: PNS is 0.589.

PSR: Safety risk is a combination of four through-run alternatives:

Alternative 1: After passing the RIP, FC are encountered at point **K** when FC re-enter the main channel from the RL channel: 8% of the FC use the RL channel below the "safe split" line at **L**. Based on MTB speeds of 27 mph, the run time from the RIP to **K** is 9.6 secs. Based on observed FC speed distribution no FC above **M** are fast enough to get to LOS **B** by the time the MTB passes **K**. The probability that FC located between **L** and **K** is positioned from **M** to **K** is 17.1% and of the FC located randomly between **M** and **K**, 71.4% are fast enough to float to **K** before the MTB passes **K** and would incur a MO. Based on these probabilities and route distribution, the weighted PSR for Alt 1 is 0.007.

Alternative 2: After passing the RIP, FC are encountered between the "safe split" line at **L** and LOS **B**: Below the safe split points, FC in either channel would be involved in an MO regardless of the channel taken by the MTB. This would involve 92% of the FC. There are two elements to this alternative: 1) All FC located between **L** and **B** at the time of MTB RIP departure would be involved in an MO. The FC route in this reach is 70.9% of the unseen routes: the PSR for this part of Alt 1 is 0.653. 2) FC in one channel could float past **L** during the MTB run time from the RIP to **L** (23 sec. at 27 mph). Observed FC speeds indicate that the fastest FC could reach **L** from 187 ft. in 23 sec. so above **I** and **J** no FC are at risk. FC speed distribution indicates that 71.1 % of the FC located from **I** and **J** to **L** could pass **L** in 23 sec. The FC route in these reaches is 29% of the unseen route in the SOC; the weighted PSR for this part of Alt 2 is 0.190. The total weighted PSR for Alt 2 is 0.843.

Alternative 3: FC is seen in the RL channel along LOS **N** from point **K**. Based on operational rules the MTB would take the RR channel: PSR for Alt. 3 is zero.

Alternative 4: FC is unseen between LOSs **N** and **O** when a MTB decides to run the RR channel at about point **D**: The MTB run time from **D** to ST1 is about 11.2 sec. at 27 mph. The FC would have to float at a minimum of 24 ft/sec. to transit from LOS **O** to **E** to incur a MO. The fastest FC observed are much slower. No FC would be at risk: PSR for Alt. 4 is zero.

Total PSR is (0.007)+(0.843)+(0)+(0)=0.850.

Notes:

Calculated risks do not include both channels occupied by FC. When FC are located both channels slow FC speeds indicate that the PSR is 1.0 if they are 111 ft. above the STs when the MTB passes the RIP and degrades towards zero if they are located at points **P** and **Q**.

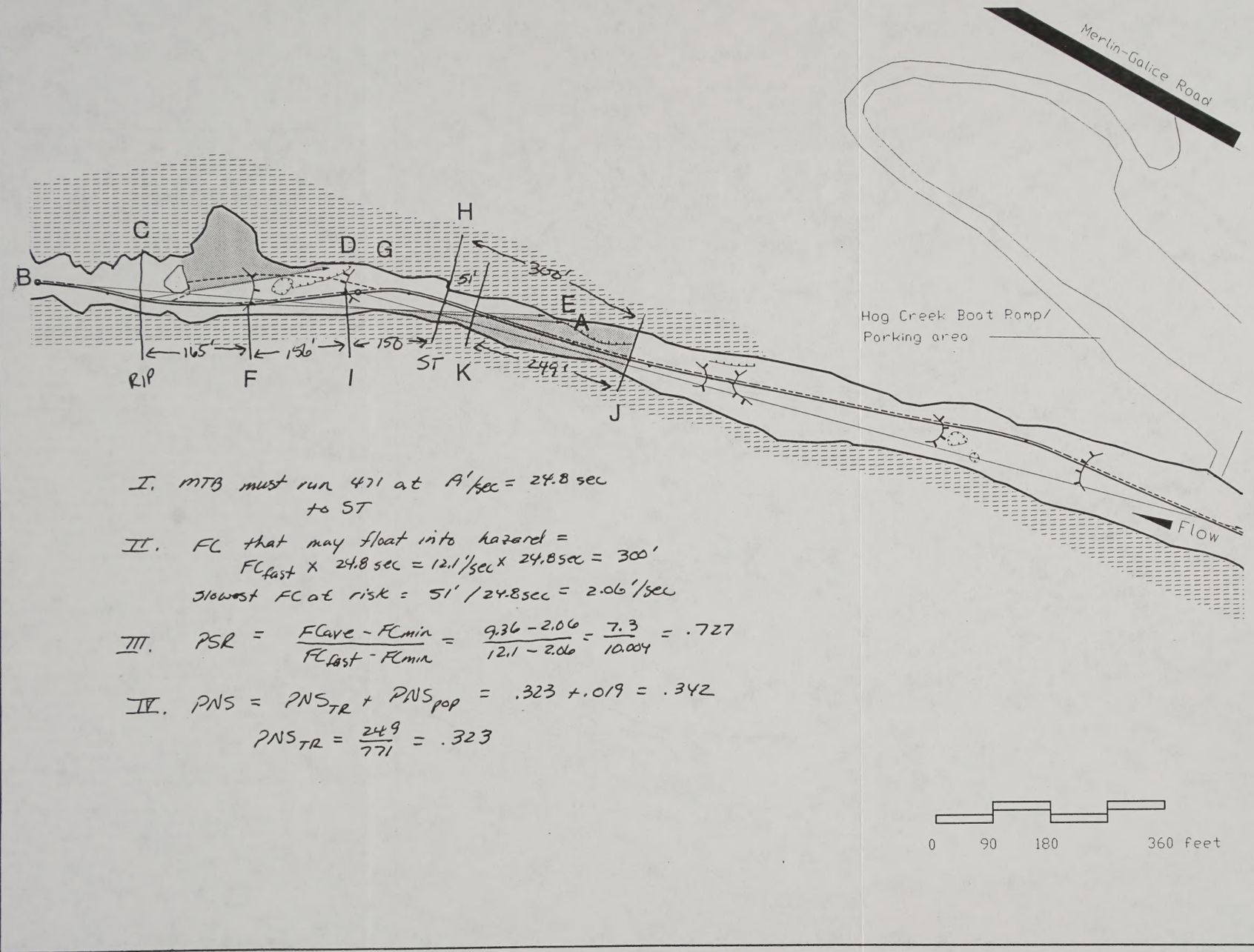
The islands and split channels of this SOC result from a balance of gravel sediment load and stream power enforced by streamflow regime and the bedrock bank at **D** through **K**. Changes in bedload and streamflow regime could lead to changes in the channel characteristics including: 1) changing set-down areas; 2) changing balance in flow between channels; 3) changing island configuration and LOS. All of these could increase or decrease PNS and PSRs year to year.

Plate 26

Rogue River Boating Safety and Conflicts Study
SOC Analysis

HELLGATE RIFFLE
Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA



I. MTB must run 471 at A'/sec = 24.8 sec
to ST

II. FC that may float into hazard =
$FC_{fast} \times 24.8\,sec = 12.1'/sec \times 24.8\,sec = 300'$
Slowest FC at risk = $51'/24.8\,sec = 2.06'/sec$

III. $PSR = \frac{FC_{ave} - FC_{min}}{FC_{fast} - FC_{min}} = \frac{9.36 - 2.06}{12.1 - 2.06} = \frac{7.3}{10.004} = .727$

IV. $PNS = PNS_{TR} + PNS_{pop} = .323 + .019 = .342$

$PNS_{TR} = \frac{249}{771} = .323$

Upstream MTB Operation

Note: The safety risks at Hellgate for upstream running MTBs are a combination of a pop-out and a float-in situation. Due to the peculiar nature of these situations at Hellgate Riffle they have different PNSs as well PSRs. The following material deals only with the float-in situation.

Approach visibility: Although the mouth of the Canyon at Sentinel Rock is visible from about 350 ft. downstream, the area above the mouth first becomes visible along LOS **A** at point **B**. The field of view improves to the RIP at **C** along LOS **D** and **E**. The critical SOC visibility is from the RIP at **C**.

RIP: The RIP is set 165 ft. below **F** to accommodate reaction time and PSD. Point **F** is the last place to stop prior to proceeding through the drop to **G**.

ST: The ST, H, is set 150 ft. above the set-down threshold at **I** to accommodate PSD and craft separation.

PNS: Based on FC route separation, of the SOC from the RIP to the ST and including a reach above the ST in which FC could float to the ST during MTB run times, 32.3% is not visible from the RIP: PNS for the float-in situation is 0.323. The PNS for the pop-out situation is 0.019 and the total PNS is 0.342.

PSR: Safety risk is the result of a float-in and a pop-out situation:

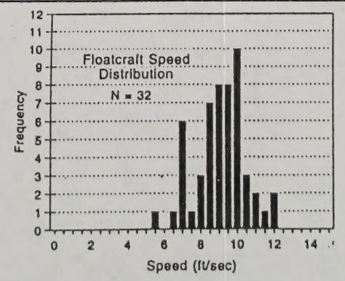
Float-in: FC are located above LOS **E** when the MTB passes the RIP: The MTB run time to the ST is 24.8 sec at an average speed of 13 mph. In 24.8 sec. the fastest FC (12.1 ft/sec.) can float 300 ft.; point **J**. Upstream of **J** no FC can float to the ST during the MTB run. From point **K**, FC must float the 51 ft. from LOS **E** and the ST in the MTB run time of 24.8 sec. to reach a position of risk; minimum float speed of 2.1 ft/sec. All FC have speeds between 2.1 and 12.1 ft/sec. Based on FC speed distribution, of randomly located FC between **K** and **J** at the moment of MTB run initiation, 72.7% would float to the ST before the MTB stopped at **G**: The PSR for the float-in risk is 0.727.

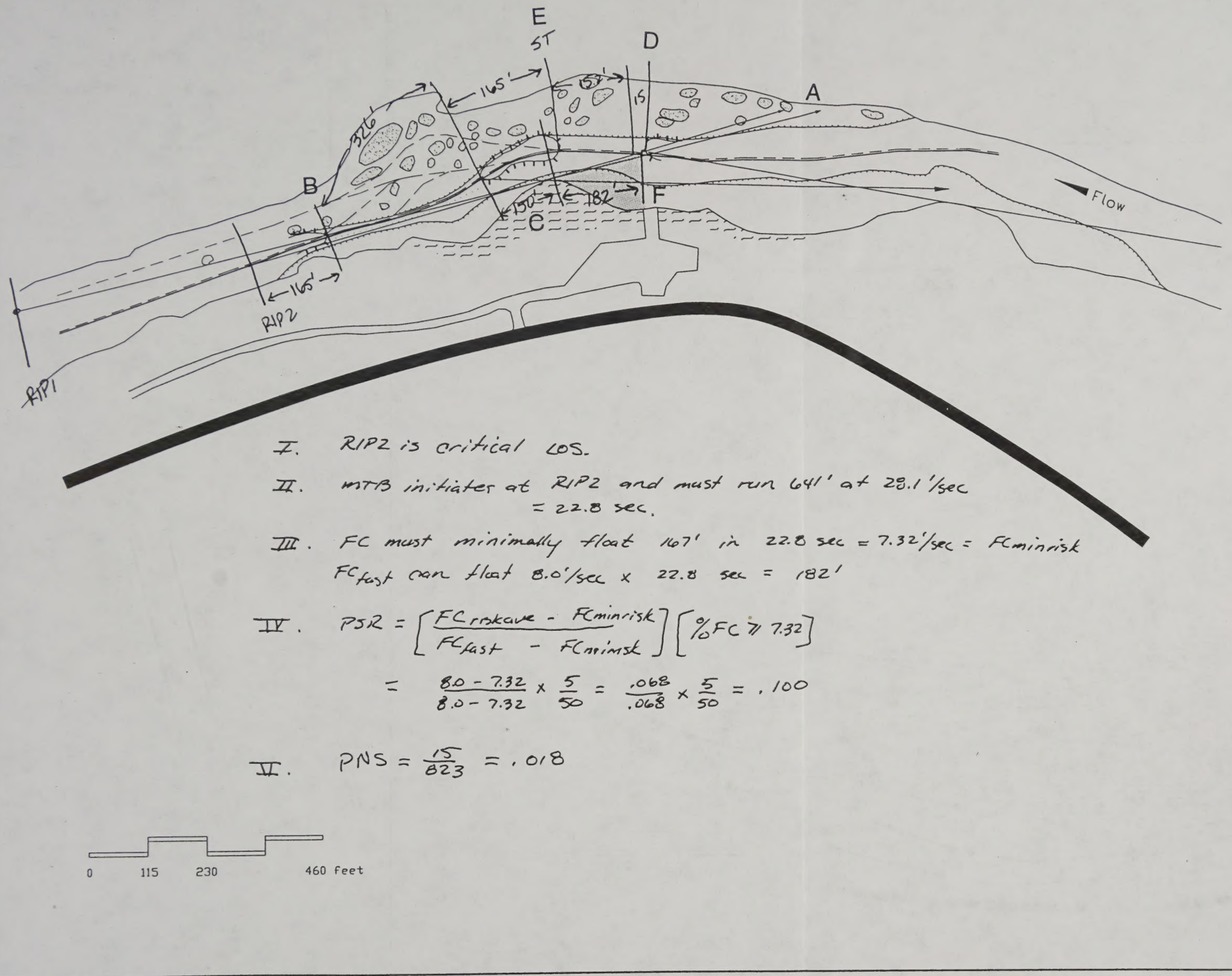
Pop-out: 8.7% of the FC could be located in the pop-out area at the moment the MTB passes the RIP (See Hellgate, low flow upstream ops., pop-out sheet for details). The PSR for the pop-out situation is 0.046.

The total PSR is (0.727)+(0.046)=0.773

Assumptions:

		Source
Slow FC Speed:	5.85 ft/sec	Field observations T2-T3
Ave FC Speed:	9.36 ft/sec	
Fast FC Speed:	12.1 ft/sec	
MTB Speed:	19.0 ft/sec	Field observations T1-T5
Other:		





I. RIP2 is critical LOS.

II. MTB initiates at RIP2 and must run 641' at 28.1'/sec = 22.8 sec.

III. FC must minimally float 167' in 22.8 sec = 7.32'/sec = FCminrisk

FC_{fast} can float 8.0'/sec x 22.8 sec = 182'

IV. $PSR = \left[\frac{FC_{riskave} - FC_{minrisk}}{FC_{fast} - FC_{minrisk}}\right]\left[\%FC \text{ @ } 7.32\right]$

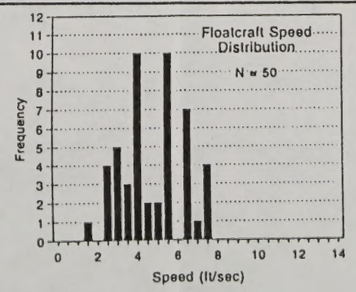
$= \frac{8.0 - 7.32}{8.0 - 7.32} \times \frac{5}{50} = \frac{.068}{.068} \times \frac{5}{50} = .100$

V. $PNS = \frac{15}{823} = .018$

0 115 230 460 Feet

Assumptions:

		Source
Slow FC Speed:	1.80 ft/sec	Field observations T2-T3
Ave FC Speed:	5.02 ft/sec	
Fast FC Speed:	8.00 ft/sec	
MTB Speed:	28.1 ft/sec	Field observations T1-T5
Other:		



Rogue River Boating Safety and Conflicts Study
SOC Analysis

ENNIS RIFFLE
High and Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA

Upstream MTB Operation

Approach visibility: RIP2 and the bottom of the SOC are continuously visible from about 935 ft. below RIP2; a run time of about 21.0 sec. at 30 mph. Sometimes MTBs will view the SOC from RIP1 but this does not add measurably to visibility. Critical visibility is from RIP2. LOS **A** originates from RIP2.

RIP: RIP2 is set 165 ft. below the set-down threshold at **B** to accommodate reaction time and PSD. MTBs can set-down in area **C** and above point **D**. Off-plane MTB/FC encounters in set-down area **C** are not MOs due to quiet hydraulics.

ST: The ST at **E** is set 165 ft. past the set-down threshold to accommodate PSD and craft separation.

PNS: Based on FC route separation, of the SOC from RIP2 to the ST and including a reach above the ST to point **F**, in which FC could float to the ST during MTB run times, 1.8% is not visible from RIP2: PNS is 0.018.

PSR: Safety risk is a float-in situation:

Float-in; FC are located between LOS **A** and point **F** when the MTB passes RIP2: The MTB run time from RIP2 to the ST is 22.8 sec. at 19.1 mph. FC must float at 7.32 ft/sec. to float from LOS **A** to the ST in 22.8 sec.; all FC slower than that would not reach the ST in time to create a MO. FC speed distribution indicates that for the FC randomly located between LOS **A** and **F**, 10% would reach the ST in time to create a MO. The PSR is 0.100

The total PSR is 0.100.

Notes:

Additional safety risk not part of the assessment are FC launching from the Ennis Ramp. Some FC could hug the RL shore in approaching set-down area **E** and could cause a close MTB on-plane pass in that area.

Rogue River Boating Safety and Conflicts Study
SOC Analysis

UPPER GALICE
High and Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA

Downstream MTB Operation

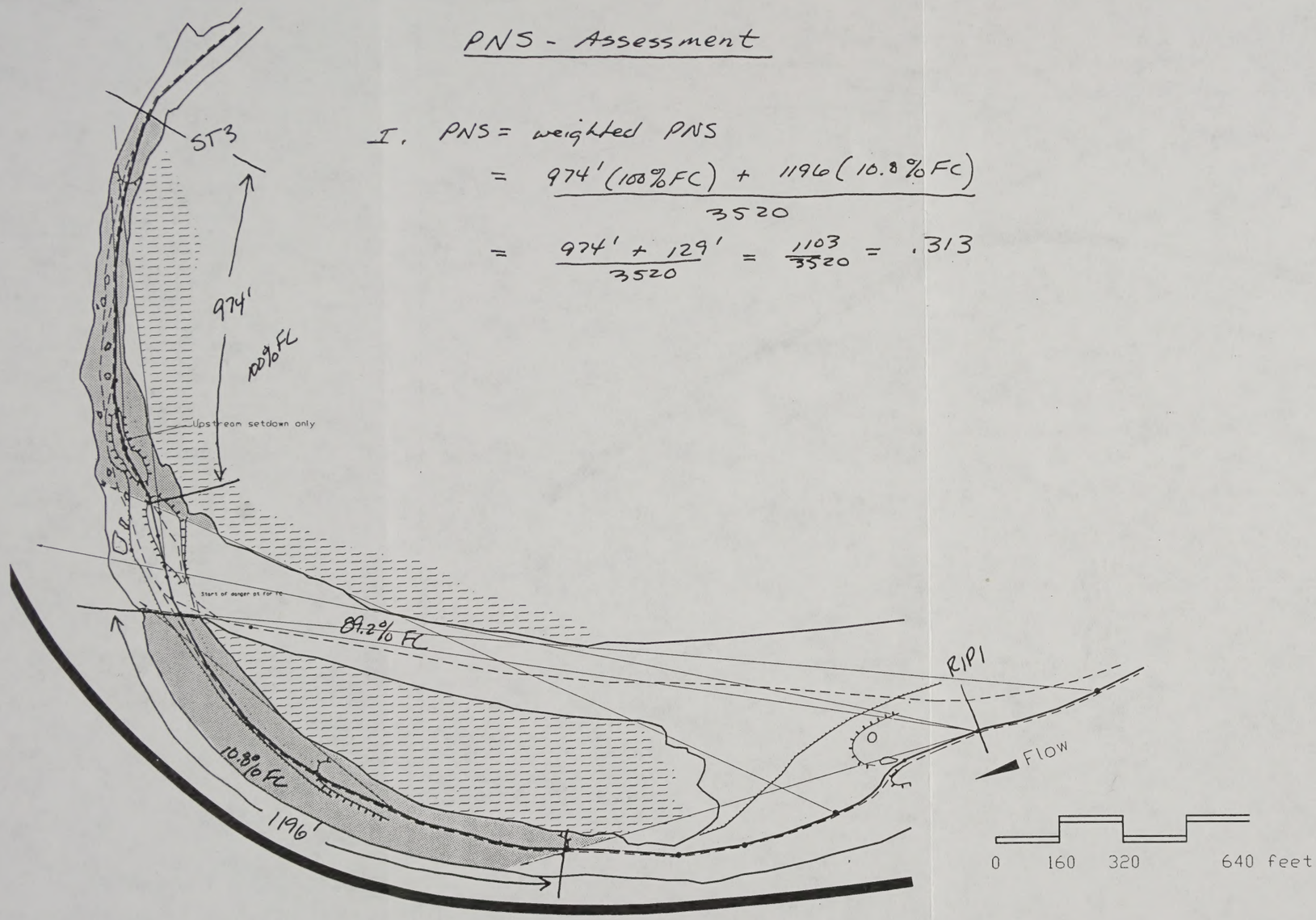
PNS Assessment

PNS - Assessment

I. PNS = weighted PNS

$$= \frac{974'(100\%FC) + 1196(10.8\%Fc)}{3520}$$

$$= \frac{974' + 129'}{3520} = \frac{1103}{3520} = .313$$



Assumptions:

		Source
Slow FC Speed:		Field observations T3-T4
Ave FC Speed:		
Fast FC Speed:		
MTB Speed:	49.5 ft/sec	Field observations T1-T4
Other:		

Plate 38

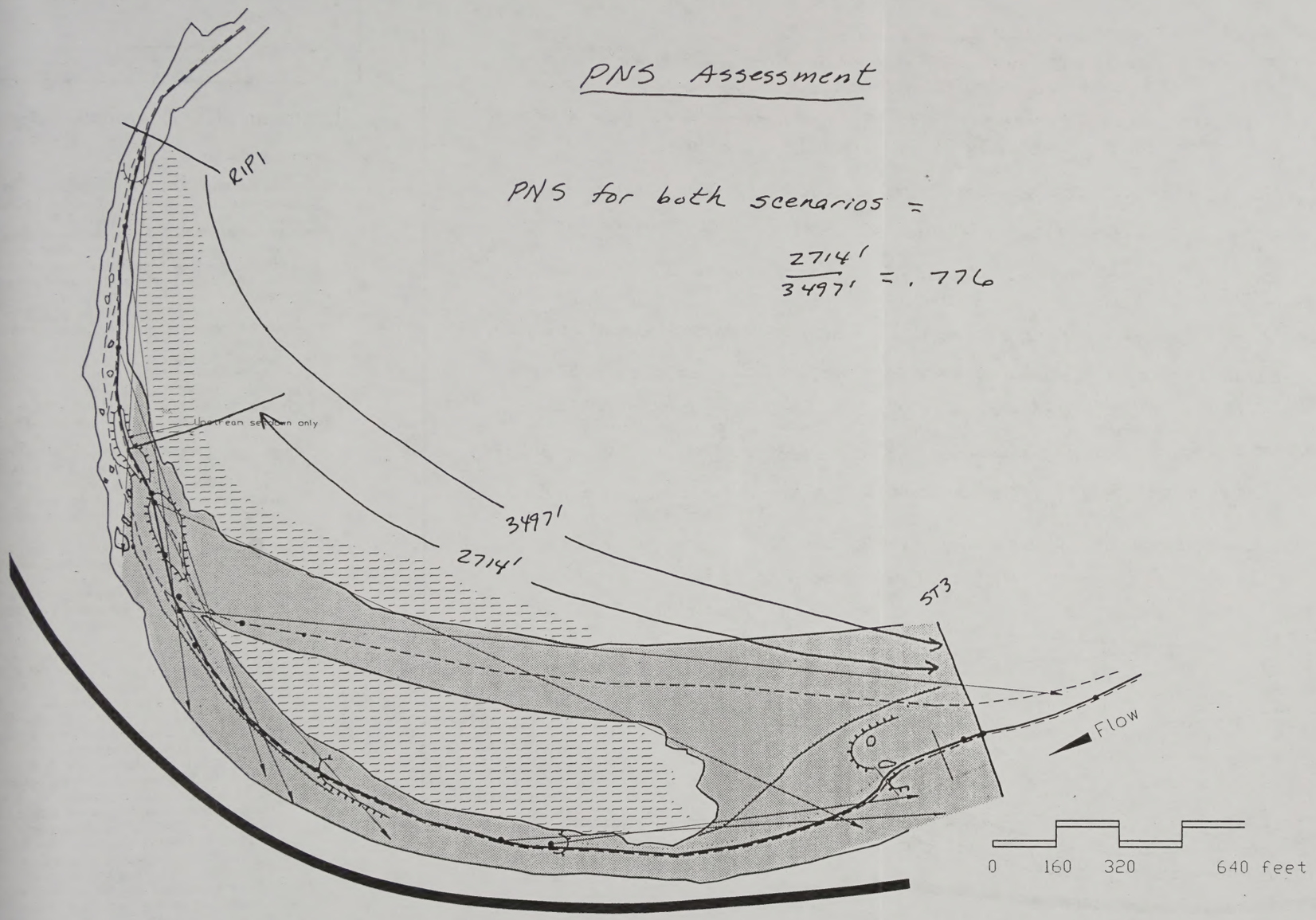
Rogue River Boating Safety and Conflicts Study
SOC Analysis

UPPER GALICE
High and Low Flow Range

Prepared by: WRC-Environmental
Secramento, CA

Upstream MTB Operation

PNS Assessment



Assumptions:

Slow FC Speed:
Ave FC Speed:
Fast FC Speed:

MTB Speed:

Other:

Plate 46

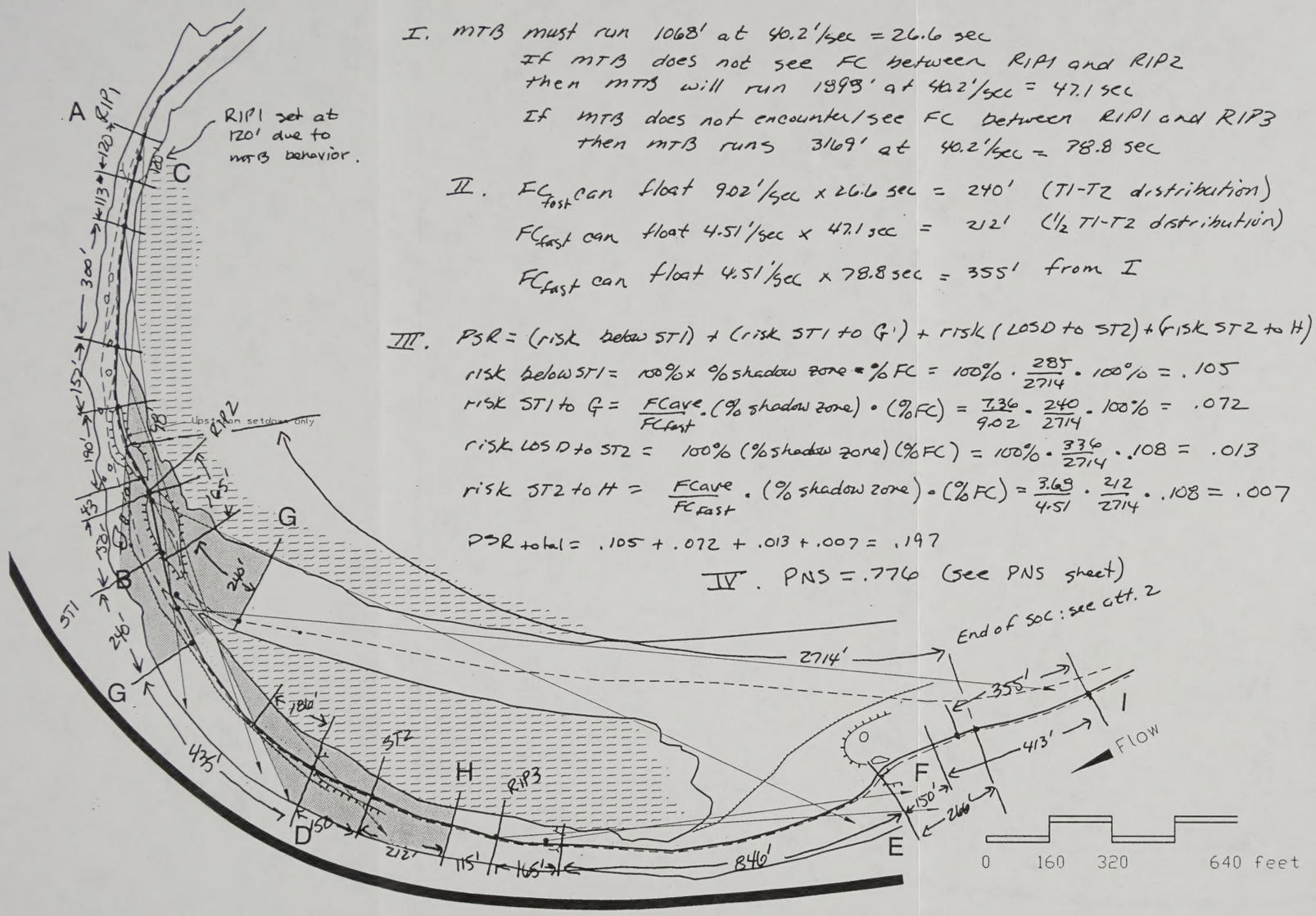
A Scenario 1: No stop at Carpenters Island (SO1)

I. MTB must run 1068' at 40.2'/sec = 26.6 sec
If MTB does not see FC between RIP1 and RIP2
then MTB will run 1893' at 40.2'/sec = 47.1 sec
If MTB does not encounter/see FC between RIP1 and RIP3
then MTB runs 3169' at 40.2'/sec = 78.8 sec

II. FC_{fast} can float 9.02'/sec x 26.6 sec = 240' (T1-T2 distribution)
FC_{fast} can float 4.51'/sec x 47.1 sec = 212' (½ T1-T2 distribution)
FC_{fast} can float 4.51'/sec x 78.8 sec = 355' from I

III. PSR = (risk below ST1) + (risk ST1 to G') + risk (LOSD to ST2) + (risk ST2 to H)
risk below ST1 = 100% x % shadow zone • % FC = $100\% \cdot \frac{285}{2714} \cdot 100\% = .105$
risk ST1 to G = $\frac{FCave}{FCfast} \cdot (\%\text{ shadow zone}) \cdot (\%FC) = \frac{7.36}{9.02} \cdot \frac{240}{2714} \cdot 100\% = .072$
risk LOS D to ST2 = $100\% \cdot (\%\text{ shadow zone}) \cdot (\%FC) = 100\% \cdot \frac{336}{2714} \cdot .108 = .013$
risk ST2 to H = $\frac{FCave}{FCfast} \cdot (\%\text{ shadow zone}) \cdot (\%FC) = \frac{3.69}{4.51} \cdot \frac{212}{2714} \cdot .108 = .007$
PSR total = .105 + .072 + .013 + .007 = .197

IV. PNS = .776 (See PNS sheet)



Assumptions:

		Source
Slow FC Speed:	4.46 ft/sec	Field observations T1-T2
Ave FC Speed:	7.37 ft/sec	Assumed 1/2 T1-T2 distribution for
Fast FC Speed:	9.02 ft/sec	areas above T1
MTB Speed:	49.5 ft/sec	Field observations T1-T4
Other:		

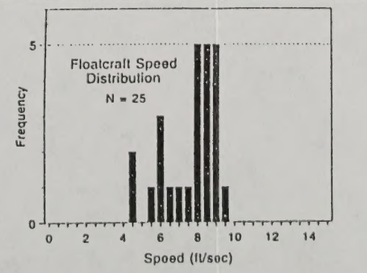


Plate 47

Rogue River Boating Safety and Conflicts Study
SOC Analysis

UPPER GALICE
High and Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA

Upstream MTB Operation

Scenario #1; No stop at Carpenter's Island

Approach visibility: RIP1 at **A** is continuously visible from about 700 ft. downstream; a run time of 15.7 sec. at 30 mph. The critical SOC visibility is from RIP1 at **A** along LOS **B**.

RIP: RIP1 is set 120 ft. below the set-down at **C** because MTBs typically initiate run from stopped attitude. RIP2 and RIP3 are set 165 ft. below the set-down thresholds to accommodate reaction time and PSD. LOS **D** and **E** originate from RIP2 and LOS **F** originates from RIP3.

ST: ST1, ST2, and ST3 are set by a SSD of 150 ft. above the respective set-down thresholds to accommodate PSD plus craft separation.

PNS: Based on FC route separation, of the SOC from the RIP to ST3 and including a reach above ST3 to point **J** (on the scenario #2 risk sheet), in which FC could float to the ST3 during MTB run times. 77.6% is not visible from RIP1: PNS is 0.776.

PSR: Safety risk is a combination of two sets of through-run and float-in situations:

Through-run #1; FC are between LOS **B** and ST1 at the moment that the MTB passes RIP1: All FC between LOS **B** and ST1 will be involved in an MO and all of the FC routes are involved. This risk area is 10.5% of the unseen portion of the SOC. When considering these three factors the weighted PSR for the through-run #1 is 0.105.

Float-in #1; FC are located between ST1 and **G1/G2** at the time the MTB passes RIP1: The MTB stops by ST1 to accommodate FC. It is assumed that the set-down area is wide and non-turbulent enough that in-floating FC when the MTB is fully stopped is not an MO encounter so the FC at potential risk are those that float past ST1 before the MTB arrives. MTB run time to ST1 is 26.6 sec. at 18.1 mph. The fastest FC (9.02 ft/sec.) can float 240 ft. in 26.6 sec; any FC located above **G1/G2** would not be at risk. Both RR and RL FC routes are involved with the float-in risk, and FC speed distribution indicates that for randomly located FC between ST1 and **G1/G2**, 81.6% would float past ST1 during the MTB run time and be at risk. This reach is 8.8% of the unseen portion of the SOC. The weighted PSR for float-in #1 is 0.072.

Through-run #2; FC are between LOS **D** and ST2 at the moment that the MTB passes RIP1: All FC between LOS **D** and ST1 will be involved in an MO, but only 10.8% of the FC in the RL channel will be involved. This risk area is 12.4% of the unseen portion of the SOC. When considering these three factors the weighted PSR for the through-run #1 is 0.013.

Float-in #1; FC are located between ST2 and **H** at the time the MTB passes RIP1: The MTB stops by ST2 to accommodate FC. It is assumed that the set-down area is wide and non-turbulent enough that in-floating FC when the MTB is fully stopped is not an MO encounter so the FC at potential risk are those that float past ST1 before the MTB arrives. MTB run time to ST2 is 47.1 sec. at 18.1 mph. The fastest FC (4.51 ft/sec.) can float 212 ft. in 47.1 sec; any FC located above **H** would not be at risk. Only the 10.8% of the FC in the RL channel are involved with the float-in risk, and FC speed distribution indicates that for randomly located FC between ST2 and **H**, 81.6% would float past ST2 during the MTB run time and be at risk. This reach is 7.8% of the unseen portion of the SOC. The weighted PSR for float-in #2 is 0.007.

The total PSR; The sum of the PSRs for this scenario is (0.105)+(0.072)+(0.013)+(0.007)=0.197. The weighted PSR for scenario #2 is 0.001 (See Upper Galice, low/high flow, upstream ops., scenario #2 risk sheet for details). Final weighted PSR is 0.198.

I. If MTB setsdown behind Carpenter's Island; info regarding FC above Carpenter's Island changes and becomes no good.

MTB runs 1161' at 40.2'/sec = 25.8 sec

II. FC_{fast} can float 4.51'/sec x 25.8 sec = 116'

III. PSR = (risk from LOS I to ST1) + (risk ST1 to J)

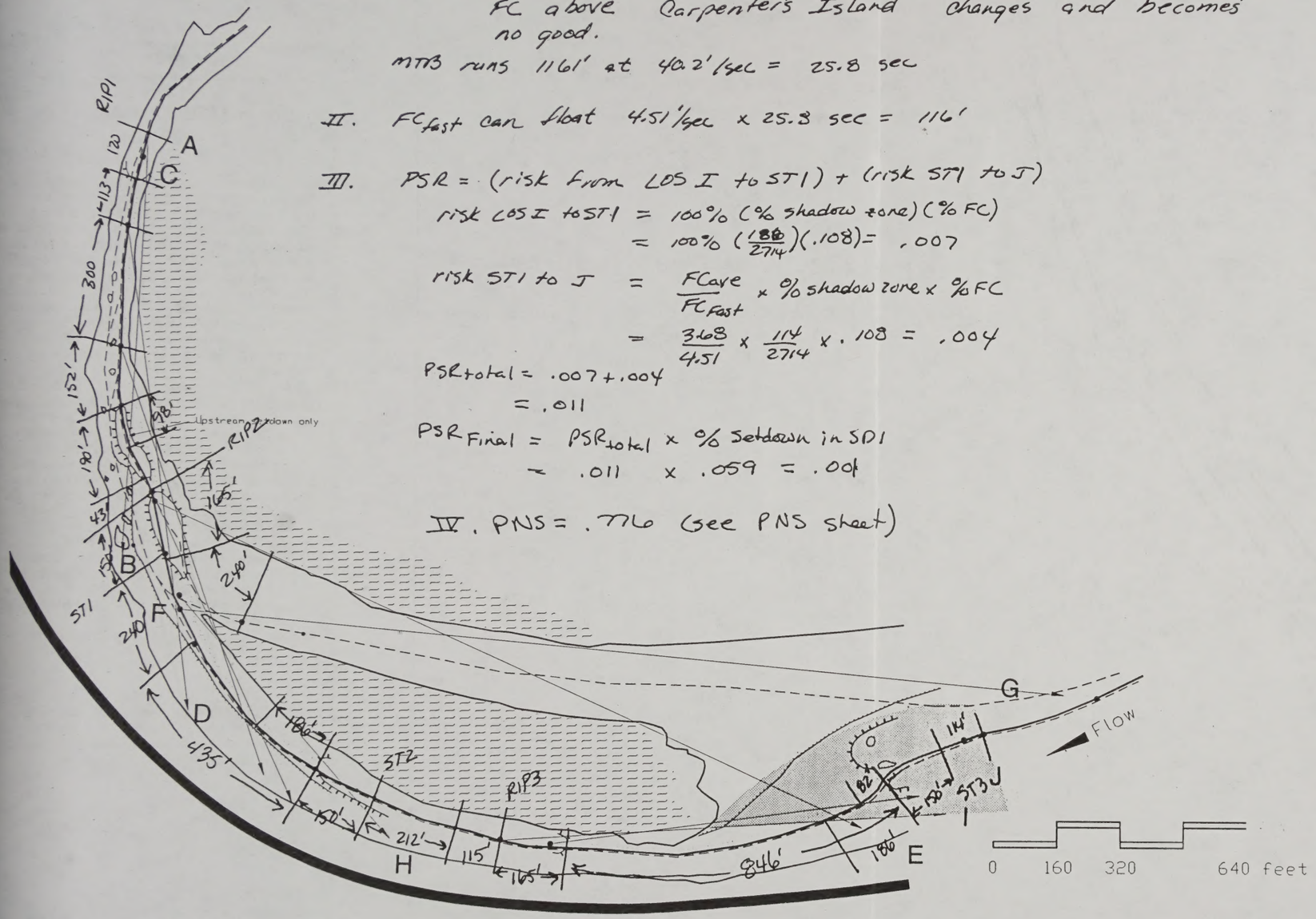
risk LOS I to ST1 = 100% (% shadow zone)(% FC)
= 100% $(\frac{186}{2714})(.108) = .007$

risk ST1 to J = $\frac{FC_{ave}}{FC_{Fast}}$ x % shadow zone x % FC
= $\frac{3.68}{4.51} \times \frac{114}{2714} \times .108 = .004$

PSR total = .007 + .004
= .011

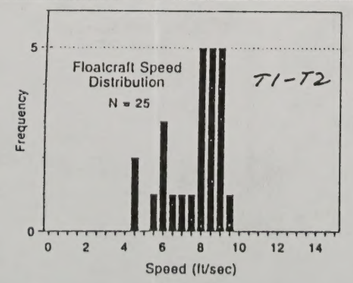
$PSR_{Final} = PSR_{total}$ x % Setdown in SD1
= .011 x .059 = .001

IV. PNS = .776 (See PNS sheet)



Assumptions:

		Source
Slow FC Speed:	4.46 ft/sec	Assumed 1/2 T1-T2 distribution for
Ave FC Speed:	7.37 ft/sec	areas above T1
Fast FC Speed:	9.02 ft/sec	
MTB Speed:	40.2 ft/sec	Field observations T1-T4
Other:		



Rogue River Boating Safety and Conflicts Study
SOC Analysis

UPPER GALICE
High and Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA

Upstream MTB Operation

Scenario #2; MTB stops at Carpenier's Island.

Approach visibility: RIP1 at **A** is continuously visible from about 700 ft. downstream; 15.7 sec. at 30 mph. The critical SOC visibility is from RIP1 at **A** along LOS **B**.

RIP: RIP1 is set 120 ft. below the set-down at **C** beacuse MTBs typically initiate run from stopped attitude. RIP2 and RIP3 are set 165 ft. below the set-down thresholds to accommodate reaction time and PSD. RIP4 is a position from which an off-plane MTB may peak upstream but run start-up would be from RIP3. LOS **D** and **E** originate from RIP2 and from point **F**, LOS **G** originates.

ST: ST1 is set by a SSD of 150 ft. above the set-down threshold to accommodate PSD plus craft separation.

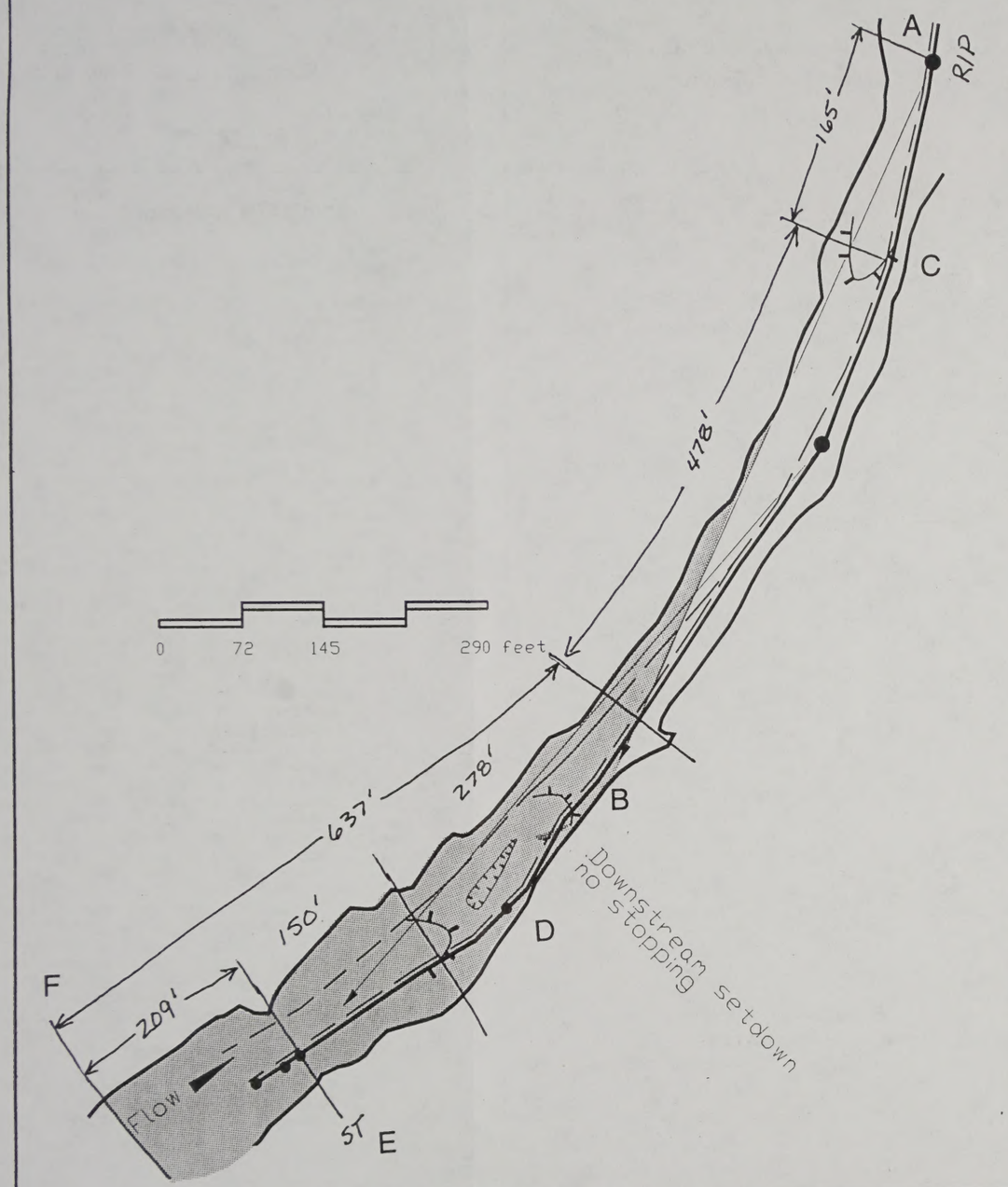
PNS: Based on FC route separation, of the SOC from the RIP to ST1 and including a reach above ST1 to points **J1** and **J2**, in which FC could float to the ST1 during MTB run times, 77.6% is not visible from RIP1: PNS is 0.776.

PSR: Safety risk is a combination of a through-run and a float-in situation:

Through-run; FC are located above LOS **I** after MTB stops at Carpenter's Island to accommodate FC on the RL route at about **H**: Between RIP2 and **F** the MTB visibility sweeps between LOS **E** and **G**. The MTB run time from **F** to ST1 is 55 sec. at 27.3 mph and in 55 sec. the fastest FC (4.51 ft/sec.) can float 248 ft. from LOS **G**. An additional 37 sec. would allow these FC to reach ST1. If the MTB stops for more than 37 sec. the FC information gathered at **F** is no longer valid. If the MTB re-initiates the run after a 37 sec. stop all FC located between LOS **I** and ST3 would be at risk, this involves 10.8% of the FC that use the RL channel. The risk area is 8.5% of the unseen portion of the SOC. When considering these three factors the weighted PSR for the through-run situation is 0.009.

Float-in; FC are located between ST3 and **J** at the time the MTB passes RIP3: The MTB stops by ST3 to accommodate FC. It is assumed that the set-down area is wide and non-turbulent enough that in-floating FC when the MTB is stopped is not an MO encounter so the FC at potential risk are those that float past ST1 before the MTB arrives. MTB run time from RIP3 to ST1 is 25.8 sec. at 27.3 mph. The fastest FC (4.51 ft/sec.) can float 114 ft. in 25.8 sec; any FC located above **J** would not be at risk. Only the 10.8% of the FC that use the RL channel would be involved, and FC speed distribution indicates that for randomly located FC between ST3 and **J**, 81.6% would float past ST1 during the MTB run time and be at risk. This reach is 4.2% of the unseen portion of the SOC. The weighted PSR for float-in the situation is 0.004.

The total PSR for Scenario #2 is 0.004. The probability of Scenario #2 occuring when there is at least one FC in the SOC is 0.059. The weighted PSR for Scenario #2 is 0.001.



I. MTB must run 1171'
at 41.1'/sec = 26.1 sec

II. FC that can float into
hazard = FC_{fast} × 26.1 sec
= 8.0'/sec × 26.1 sec
= 209'

III. PSR = (risk above ST) + (risk below ST)

risk above ST = $\frac{FCave}{FCfast}$ × % shadow zone

= $\frac{502}{8.0} \times \frac{209}{637}$ = (.628)(.328)

= .206

risk below ST = 100% × % shadow zone

= 100% × $\frac{428}{637}$

= .672

PSR total = .206 + .672 = .879

IV. PNS = $\frac{637}{1280}$ = .498

Assumptions:

		Source
Slow FC Speed:	1.80 ft/sec	Field observations at T1-T2 too fast
Ave FC Speed:	5.02 ft/sec	to represent speeds above T1
Fast FC Speed:	8.00 ft/sec	Speeds/distribution above T1 assumed to be similar to T1-T2 in Ennis
MTB Speed:	41.1 ft/sec	Field observations T1-T4
Other:		

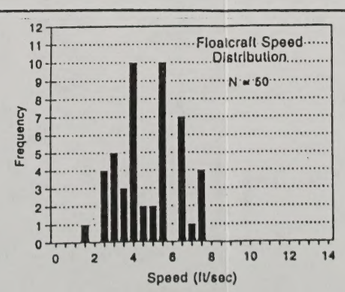


Plate 51

Rogue River Boating Safety and Conflicts Study
SOC Analysis

LOWER GALICE
High and Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA

Upstream MTB Operation

Approach visibility: Although the RIP, point **A**, and the bottom of the SOC are continuously visible from about 1400 ft. below the RIP the critical SOC visibility is at the RIP. LOS **B** originates from the RIP.

RIP: The RIP is set 165 ft. below the set-down threshold at **C** to accommodate reaction time and PSD. MTBs can set-down to stop in most places through to **D** however these MTB/FC encounters would be considered as MOs due to water velocity and turbulence.

ST: The ST at **E** is set by a SSD of 150 ft. above the set-down threshold to accommodate PSD plus craft separation.

PNS: Based on FC route separation, of the SOC from the RIP to the ST and including a reach above the ST to point **I**, in which FC could float to the ST during a MTB run, 49.8% is not visible from the RIP: PNS is 0.498.

PSR: Safety risk is a combination of through-run and float-in situations:

Through-run: FC are between LOS **B** and the ST at the moment the MTB passes the RIP: All FC in this area will be at risk regardless of FC speed. The area between LOS **B** and the ST is 428 ft. or 67.2% of the unseen portion of the SOC: The weighted PSR for the through-run situation is 0.672.

Float-in: FC are located between the ST and point **F** when the MTB passes the RIP: The MTB run time from the RIP to the ST is 26.1 sec at 28 mph. In 26.1 sec. the fastest FC (8.0 ft/sec.) can float 209 ft.; from point **F** to the ST. Upstream of **F** no FC can float to the ST during the MTB run. FC speed distribution indicates that of the FC randomly located between **F** and the ST at the time the MTB run initiation, 62.8% can float past the ST and be involved in a MO. This area is 32.8% of the unseen portion of the SOC: The weighted PSR for the float-in situation is 0.206.

The total PSR is (0.672)+(0.206)=0.879

Notes:

If as MTB passes **A** off-plane before initiating the run LOS conditions improve, PNS is reduced, and the PSR for the through-run risks could be reduced by about 25%. (about 0.500).

I. MTB initiates at RIP and must run
725' on-plane to ST
725' at 38.8'/sec = 18.7 sec

II. FC that can float into hazard at ST
$= FC_{fast} \times 18.7\,sec = 4.9'/sec \times 18.7\,sec = 91'$

III. $PSR = \left[\%\ shadow\ zone \times \frac{FC_{ave}}{FC_{fast}}\right] + \frac{330}{421}\ (100\%)$

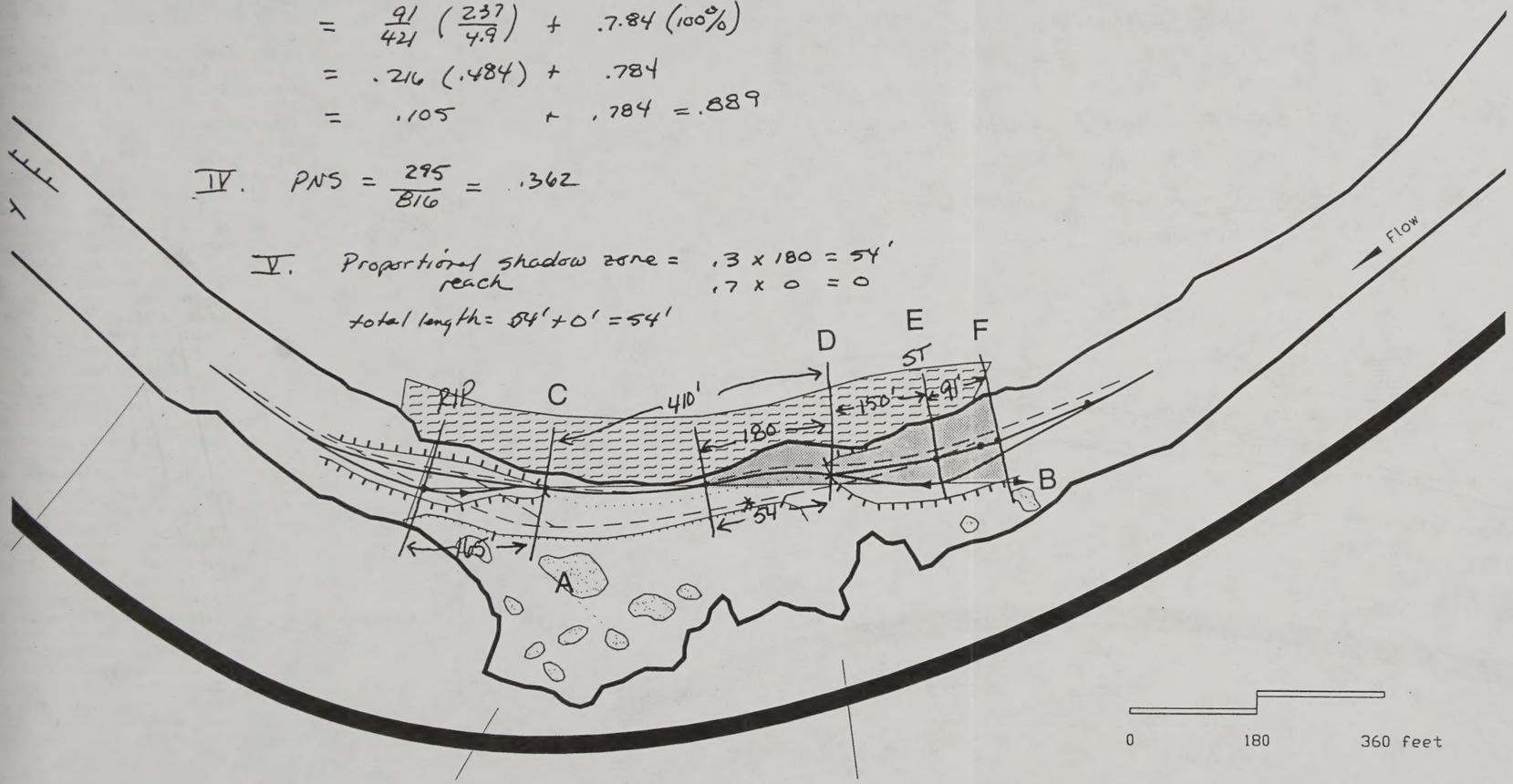
$= \frac{91}{421}\left(\frac{2.37}{4.9}\right) + .7.84\ (100\%)$

$= .216\ (.484) + .784$

$= .105 + .784 = .889$

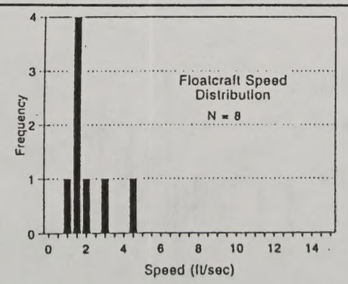
IV. $PNS = \frac{295}{816} = .362$

V. Proportional shadow zone = reach
$.3 \times 180 = 54'$
$.7 \times 0 = 0$
total length = $54' + 0' = 54'$



Assumptions:

		Source
Slow FC Speed:	1.27 ft/sec	Field observations above T1
Ave FC Speed:	2.37 ft/sec	
Fast FC Speed:	4.90 ft/sec	
MTB Speed:	38.8 ft/sec	Field observations T1-T4
Other:		



Rogue River Boating Safety and Conflicts Study
SOC Analysis

ARGO
High and Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA

Upstream MTB Operation

Approach visibility: Although the RIP through to point **A**, are continuously visible from about 1600 ft. below the RIP the critical SOC visibility is at the RIP. LOS **B** originates from the RIP.

RIP: The RIP is set 165 ft. below the set-down threshold at **C** to accommodate reaction time and PSD. MTBs can not set-down until past **D**.

ST: The ST at **E** is set by a SSD of 150 ft. above the set-down threshold to accommodate PSD plus craft separation.

PNS: Based on FC route separation, of the SOC from the RIP to the ST and including a reach above the ST to point **F**, in which FC could float to the ST during the MTB run, 36.2% is not visible from the RIP: PNS is 0.362.

PSR: Safety risk is a combination of through-run and float-in situations:

Through-run; FC are between LOS **B** and the ST at the moment the MTB passes the RIP: All FC in this area will be at risk regardless of FC speed. The area between LOS **B** and the ST is 330 ft. or 78.4% of the unseen portion of the SOC: The weighted PSR for the through-run situation is 0.784.

Float-in; FC are located between the ST and point **F** when the MTB passes the RIP: The MTB run time from the RIP to the ST is 18.7 sec. at 26.4 mph. In 18.7 sec. the fastest FC (4.9 ft/sec.) can float 91 ft.; from point **F** to the ST. Upstream of **F** no FC can float to the ST during the MTB run. FC speed distribution indicates that of the FC randomly located between **F** and the ST at the time the MTB run initiation, 48.4% can float past the ST. This area is 21.6% of the unseen portion of the SOC: The weighted PSR for the float-in situation is 0.105.

The total PSR is (0.784)+(0.105)=0.889

Plate 63

I. MTB gets best LOS above rock from A
MTB gets best LOS below rock at RIP
MTB run time from A to RIP = 372' at 42.8'/sec = 8.7 sec
MTB must run on-plane from RIP to ST = 847' at 42.8'/sec = 19.8 sec

II. FC slow can float 2.37'/sec x 8.7 sec = 21' during MTB run time from A to RIP
weighted average float line to ST = R1%(200') + R2%(148') + R3%(99')
= .2(200') + .6(148') + .15(99')
= 40 + 88.8 + 14.9 = 143.7'

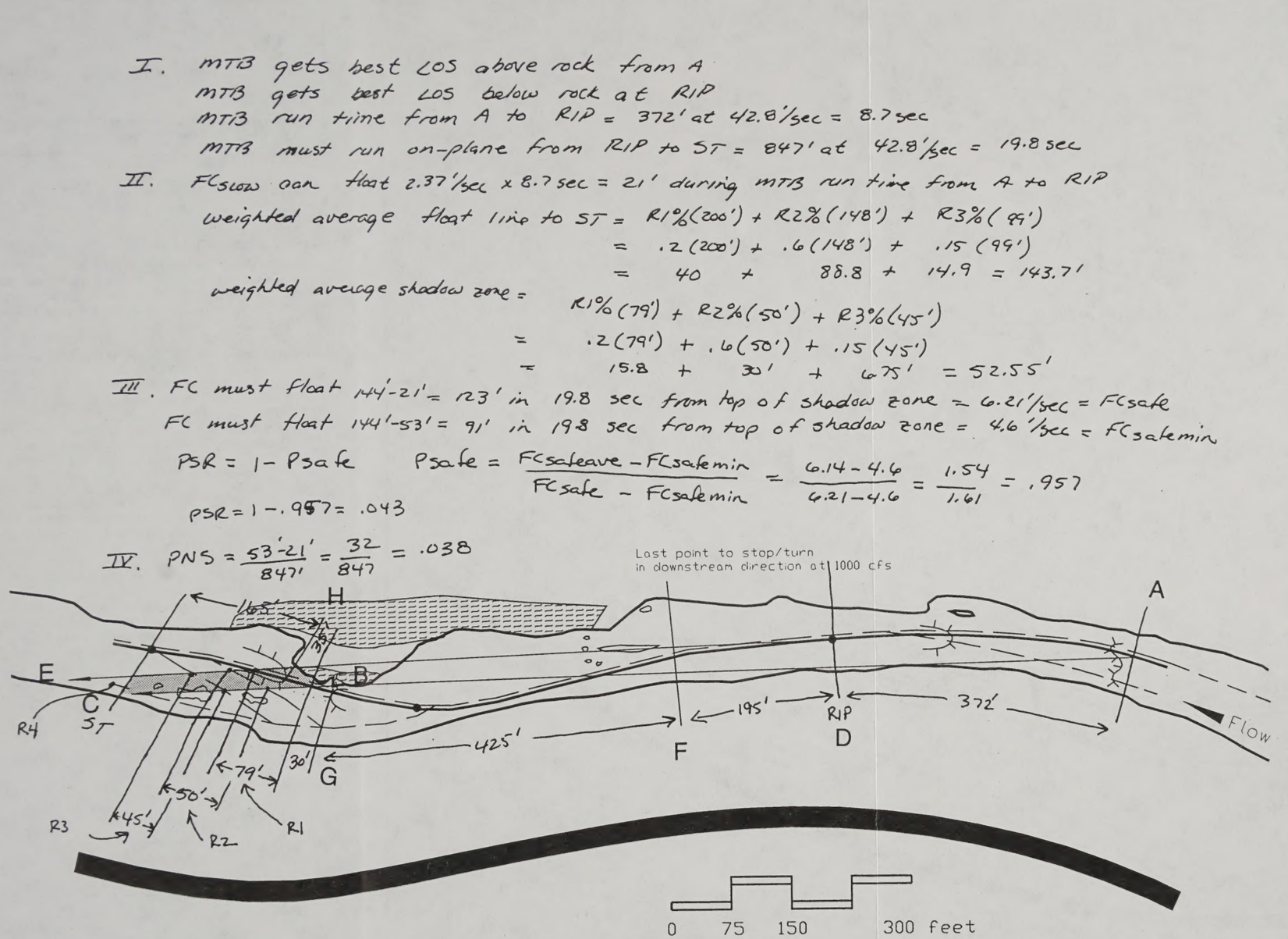
weighted average shadow zone = R1%(79') + R2%(50') + R3%(45')
= .2(79') + .6(50') + .15(45')
= 15.8 + 30' + 6.75' = 52.55'

III. FC must float 144'-21' = 123' in 19.8 sec from top of shadow zone = 6.21'/sec = FCsafe
FC must float 144'-53' = 91' in 19.8 sec from top of shadow zone = 4.6'/sec = FCsafemin

PSR = 1 - Psafe $P_{safe} = \frac{FC_{safeave} - FC_{safemin}}{FC_{safe} - FC_{safemin}} = \frac{6.14 - 4.6}{6.21 - 4.6} = \frac{1.54}{1.61} = .957$

PSR = 1 - .957 = .043

IV. $PNS = \frac{53' - 21'}{847'} = \frac{32}{847} = .038$



Assumptions:

		Source
Slow FC Speed:	3.56 ft/sec	Assumed FC speeds similar to L. Galice T1-T3
Ave FC Speed:	8.53 ft/sec	Field observations/records
Fast FC Speed:	11.90 ft/sec	Speeds field checked with floats by field staff
MTB Speed:	34.0 ft/sec	Assumed similar speeds as in L. Galice T1-T3: Observations
Other:		

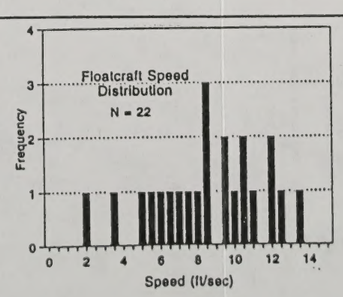


Plate 64

Rogue River Boating Safety and Conflicts Study
SOC Analysis

WOOLDRIDGE RIFFLE
Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA

Downstream MTB Operation

Approach visibility: From Point **A** the RIP and the RL side of the "rock", **B**, is visible along LOS **C**. In 8.7 Sec. the MTB reaches the RIP at 29.1 mph. where the best view to the RR side of the "rock" is obtained along LOS **E**. Critical visibility is from the RIP.

RIP: The last MTB stopping point is at **F**. To **G** MTBs can not effectively set-down to drift, drift, and get back on-plane in time to pass **G** on-plane; MTBs can not drift from **G** to **H**. The RIP is set by a SSD of 195 ft. above **F** to accommodate reaction time, and PSD in a 'narrow' set-down area.

ST: The ST is set by a SSD of 165 ft. below the set-down threshold at **H** to accommodate PSD plus craft separation.

PNS: Based on FC route separation, of the SOC from the RIP to the ST, 3.8% is unseen: The PNS is 0.038.

PSR: Safety risk is a result of a through-run situation:

Through-run; FC are between LOS **C** when the MTB passes **A** and LOS **E** when the MTB passes the RIP: The FC are on 4 routes, 3 of which are related to potential MTB risk. 95% of the FC at potential risk. When weighted for FC route separation, LOS **C** is located 144 ft. above the ST, the weighted shadow zone length to LOS **E** is 53 ft., and the weighted channel length between LOS **E** and the ST is 90 ft. During the MTB run time from **A** to the RIP (8.7 sec.) slow FC (2.37 ft/sec.) can float 21 ft. downstream of LOS **C**. When the MTB is at the RIP the effective shadow zone is the width of the shadow zone (53 ft.) minus the slow FC float distance (21 ft.); 32 ft. The FC risk bracket situations in which a slow FC is located 123 ft. above the ST and any FC is located 90 ft. above the ST when the MTB passes the RIP. The MTB run time from the RIP to the ST is 19.8 sec. at 29.1 mph. At 6.21 ft/sec. FC can float from a point 21 ft. below LOS **C** past the ST in 19.8 sec.; therefore all FC with speeds of 6.21 ft/sec. and faster located anywhere in the shadow zone will pass the ST in time to avoid a MO. At 4.6 ft/sec. a FC can float from LOS **E** to the ST in 19.8 sec.; therefore no FC slower than 4.6 ft/sec. located anywhere in the shadow zone will float past the ST in time. Some randomly located FC in the shadow zone with speeds between 4.6 and 6.21 will pass the ST in time to avoid a MO. FC speed distribution indicated that 95.7% of the FC randomly located in the effective shadow will float past the ST in time to avoid a MO. The PSR is 0.043

The total PSR is 0.043.

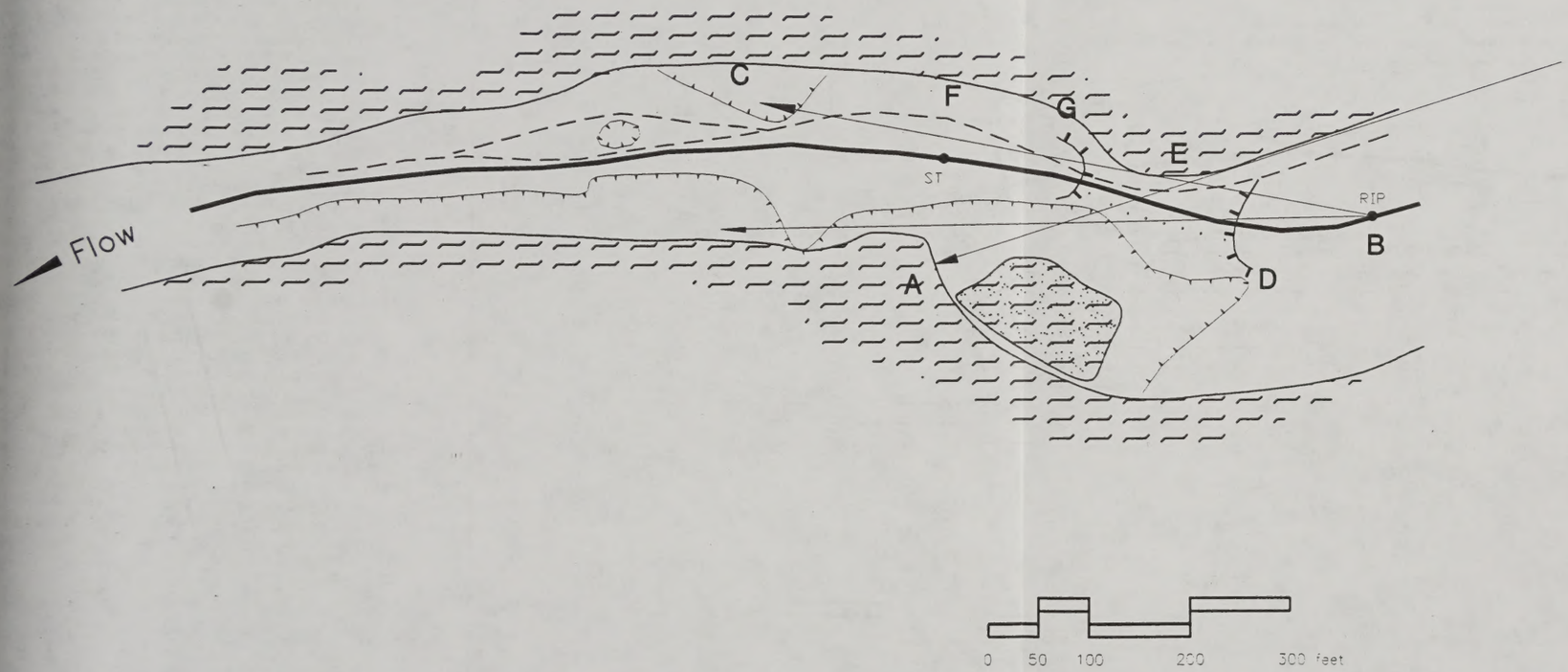
Notes:

Potential safety risks not observed in 1992 include FC beaches on the downstream side of the "rock" and staying in the shadow zone during the MTB approach. This would be a MO if the FC is in the water. This would be a pop-out, time dependency would be a function of user patterns.

Rogue River Boating Safety and Conflicts Study
SOC Analysis

FIRST DROP
Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA



Downstream MTB Operation

Approach visibility: The top of the SOC can be seen along LOS **A** from a point about 1000 ft. above the RIP at **B**; about 34.1 sec. to the RIP at 20 mph. From the RIP at **B** view into the SOC in along LOS **C**. It is 125 ft. along the FC float line from LOS **A**, at about **E**, to LOS **C**, at about **G**, and about 325 ft. to LOS **C** near the bottom of the SOC. Any FC that is seen from the RIP to about point **G** and not seen during the MTB approach would have to float the 125 ft. in less than 34.1 sec.; less than 3.7 ft/sec. For a FC to be visible from both the approach visibility point and the RIP it would have to float the 325 ft. in 34.1 sec.; 9.5 ft/sec. FC float speeds from the Hellgate SR indicate that the fastest FC speed in this area would be about 10.1 ft/sec. and the slowest about 5.4 ft/sec. Therefore FC located at **E** when the visibility along LOS **A** is first achieved with speeds between 5.4 and 9.5 ft/sec. would not be visible from either the approach point nor the RIP. This speed range would include most of the FC. The RIP and the approach points are both critical visibility locations. Although FC in the SOC could have been observed from the approach visibility point but not seen from the RIP, it is assumed the MTB would stop at the RIP to wait until the FC pass the lower LOS **C** before run initiation. The RIP at point **B** offers the best SOC visibility along LOS **C** before the MTB is committed to running; the RIP is the critical visibility point.

RIP: The last MTB stopping point is at **D**; they can not drift through the sill at **E** but can stop at point **F**. The RIP at **B** is set by a SSD of 138 ft. above the set-down threshold to accommodate craft footprint, reaction time, and PSD in a 'wide' set-down area.

ST: The ST at **F** is set by a SSD of 138 ft. below the set-down threshold to accommodate PSD plus craft separation.

PNS: Of the SOC from the RIP to the ST (425 ft.) about 80 ft. of the FC float route is not visible from the RIP (18.8%): The PNS is 0.188.

PSR: Safety risk is a result of a through-run situation:

Through-run; If FC are located between points **G** and **F** at the moment the MTB passes the RIP they could be overtaken at or above point **F** by the MTB. The MTB run time from the RIP to the ST is 14.5 sec. (425 ft. at 20 mph). If a FC is located at **G** when the MTB passes the RIP it would have 14.5 sec. to float the 80 ft. to **F** to avoid a MO situation. Any FC faster than 5.5 ft/sec. would be able to pass **F** before an approaching MTB arrives at **F** and stops. Typical FC speed distribution at similar SOCs in the Hellgate Study Reach indicate that all but the very slowest FC would have float speeds greater than 5.5 ft/sec. in swift tailwater such as that at this location. The potential safety risk exposure at this location is small.

A very short MTB wait at the RIP could eliminate potential safety risks. In addition MTBs can pass point **E** to the RL side and avoid MTB/FC encounters at less than MO thresholds.

Assumptions: Source

Slow FC Speed:
Ave FC Speed:
Fast FC Speed:

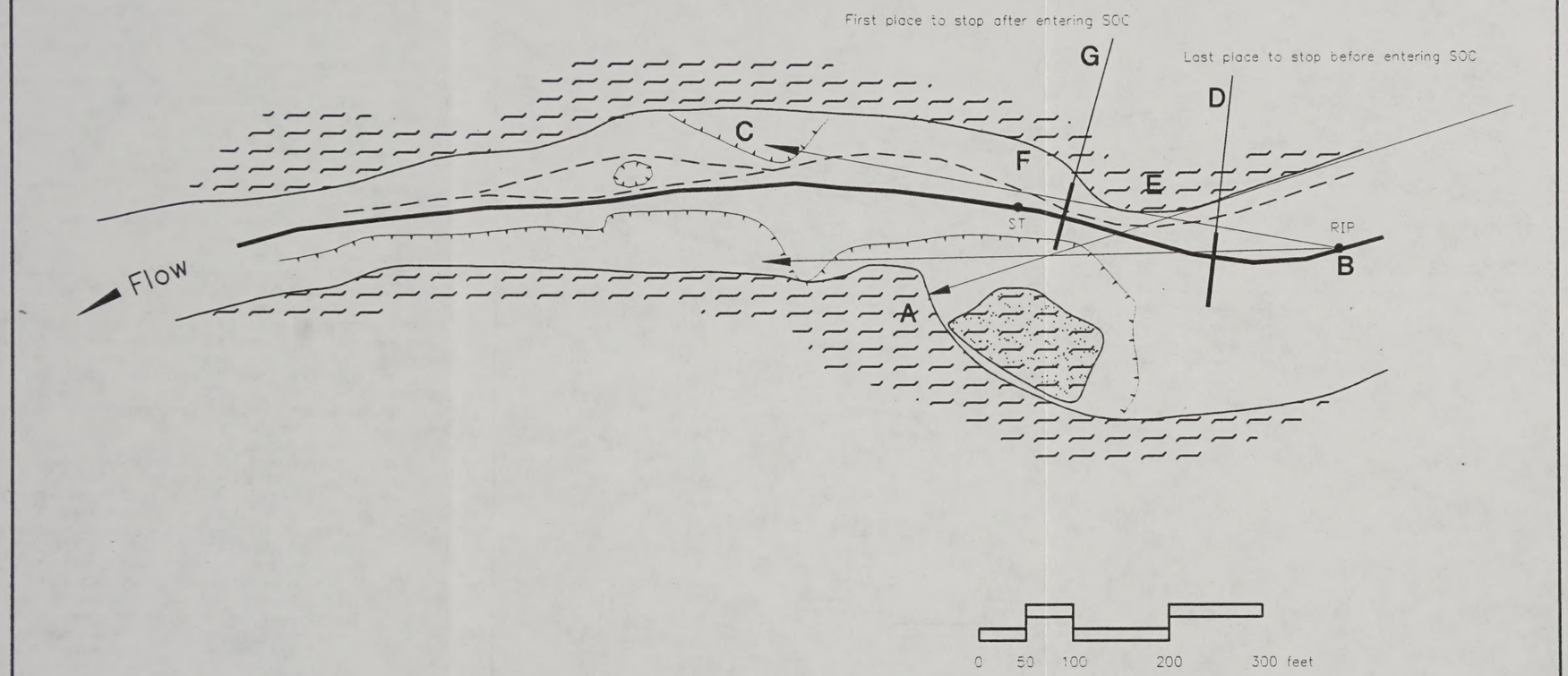
MTB Speed:

Other:

Rogue River Boating Safety and Conflicts Study
SOC Analysis

FIRST DROP
High Flow Range

Prepared by: WRC-Environmental
Sacramento, CA



Downstream MTB Operation

Approach visibility: The top of the SOC can be seen along LOS **A** from a point about 1000 ft. above the RIP at **B**; about 34.1 sec. to the RIP at 20 mph. From the RIP at **B** view into the SOC in along LOS **C**. It is 125 ft. along the FC float line from LOS **A**, at about **E**, to LOS **C**, at about **G**, and about 325 ft. to LOS **C** near the bottom of the SOC. Any FC that is seen from the RIP to about point **G** and not seen during the MTB approach would have to float the 125 ft. in less than 34.1 sec.; less than 3.7 ft/sec. For a FC to be visible from both the approach visibility point and the RIP it would have to float the 325 ft. in 34.1 sec.; 9.5 ft/sec. FC float speeds from the Hellgate SR indicate that the fastest FC speed in this area would be about 10.1 ft/sec. and the slowest about 5.4 ft/sec. Therefore FC located at **E** when the visibility along LOS **A** is first achieved with speeds between 5.4 and 9.5 ft/sec. would not be visible from either the approach point nor the RIP. This speed range would include most of the FC. The RIP and the approach points are both critical visibility locations. Although FC in the SOC could have been observed from the approach visibility point but not seen from the RIP, it is assumed the MTB would stop at the RIP to wait until the FC pass the lower LOS **C** before run initiation. The RIP at point **B** offers the best SOC visibility along LOS **C** before the MTB is committed to running; the RIP is the critical visibility point.

RIP: The last MTB stopping point is at **D**; they can drift through the sill at **E** and stop at point **E**. The RIP at **B** is set by a SSD of 138 ft. above the last stopping point to accommodate either a stop using craft footprint, reaction time, and PSD in a 'wide' set-down area, or a stop to drift using craft footprint, reaction time, and PSD.

ST: The ST at **F** is set by a SSD of 50 ft. below the first place that a MTB can execute a stop at point **G** to accommodate craft footprint and SSD assuming that the MTB is drifting.

PNS: Of the SOC from the RIP to the ST (325 ft.) about 10 ft. of the FC float route is unseen: The PNS is .031.

PSR: At a MTB drifting speed of about 10 ft/sec. the MTB can run to the ST in 4.7 sec. on-plane to **D** and 21.5 sec. drifting 215 ft. from **D** to **F**; a total of 27.2 sec. Only those FC that can not float the 10 ft. to **F** in 27.2 sec (<0.4 ft/sec.) would be at risk. No potential inadvertent safety risks are identified.

Assumptions: Source

Slow FC Speed:
Ave FC Speed:
Fast FC Speed:

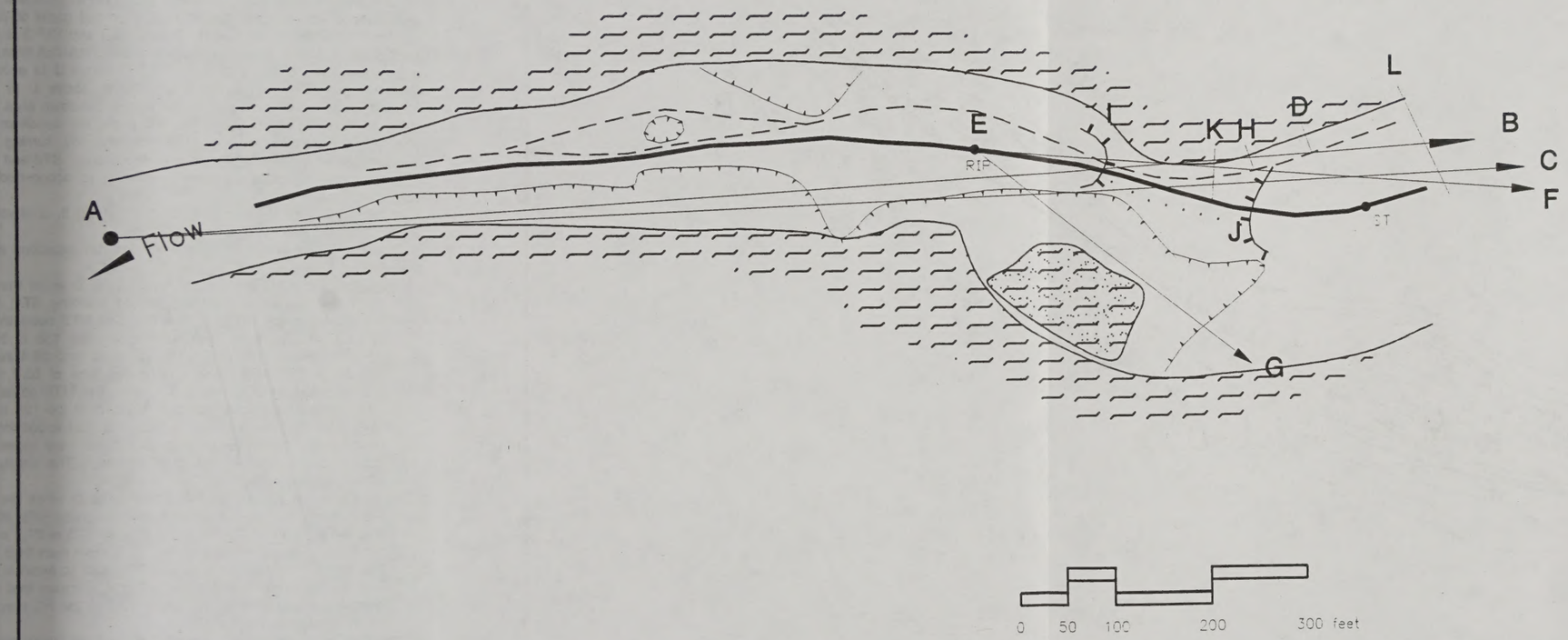
MTB Speed:

Other:

Rogue River Boating Safety and Conflicts Study
SOC Analysis

FIRST DROP
High & Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA



Upstream MTB Operation

Approach visibility: From point **A**, about 910 ft. below the RIP, the SOC can be viewed along LOS **B** and LOS **C** and all FC below point **D** are visible. As the MTB approaches the RIP views of the SOC widen until the RIP at point **E** is reached and the SOC is visible between LOS **F** and LOS **G** and all FC below point **H** are visible. For point **A** to be the critical visibility point FC would have to float from **D** to **H** in less time than the MTB can run from **A** to **E**. At 20 mph the MTB would run the 910 ft. from **A** to **E** in 31.1 sec. If FC float the 40 ft. from **D** to **H** in more than 31.1 sec. they would have float speeds of less than 1.3 ft/sec. FC float speed information from the Hellgate Study Reach indicate that all FC should have speeds faster than 1.3 ft/sec; therefore it is possible that FC unobserved from **A** would be observed from **E**. The critical visibility point is from the RIP at **E**.

RIP: The RIP is set **138 ft below** the set-down threshold at **I** to accommodate reaction time and PSD. At high flows the MTBs can set-down between **I** and **J** by any stops there to accommodate FC would be a MO.

ST: The ST is set **125 ft. past** the set-down threshold at **J** to accommodate PSD and craft separation.

PNS: Of the SOC from the RIP to the ST along the FC float route about 110 ft. is unseen, this is 24.4% of the 450 ft. long SOC: The PNS is 0.244

PSR: Safety risks are result from a combination of through-run risk and a float-in risk:

Through-run; Between **H** and **I** the MTB and FC routes converge and at about **K** the routes closure reaches about 25 ft. At 20 mph the MTB run time for the 230 ft. from the RIP to point **K** is 7.8 sec. A FC located just above **H** at the moment that the MTB passes the RIP would need a float speed greater than 7.1 ft/sec. to float 55 ft. from **H** to **K** in time to encounter the MTB at **K**. FC float speed information from the Hellgate Study reach indicated that from 30-50% of the FC could have speeds greater than 7 ft/sec., therefore a high percentage of FC located in the vicinity of **H** when the MTB run is initiated could be placed at potential risk. Should a MTB/FC encounter occur anywhere in the reach between **H** and **I** that leads to FC upset or throws the FC off course, swimmers/ floaters could be swept along the RR bank which has very high water velocities running along an undercut bank and through trees that form strainers. This could be a serious MO situation.

Float-in; If FC are located along the MTB route just above LOS **F** at point **L**, FC could float into the ST area before the MTB reaches the ST and is fully stopped. The MTB run time for the 440 ft. from the RIP to the ST is 15 sec. at 20 mph. FC would need a float speed of 5.7 ft/sec. to float the 85 ft. between **L** and the ST in time to be involved in a MO. Observations from the Hellgate Study Reach indicates that most all drifting FC at this location would have float speeds less than 5.7 ft/sec. But FC under paddle or oar power could easily have speeds greater than 6 ft/sec. in the location. Therefore inadvertent float-in safety risks at the ST are possible.

Assumptions: Source

Slow FC Speed:
Ave FC Speed:
Fast FC Speed:

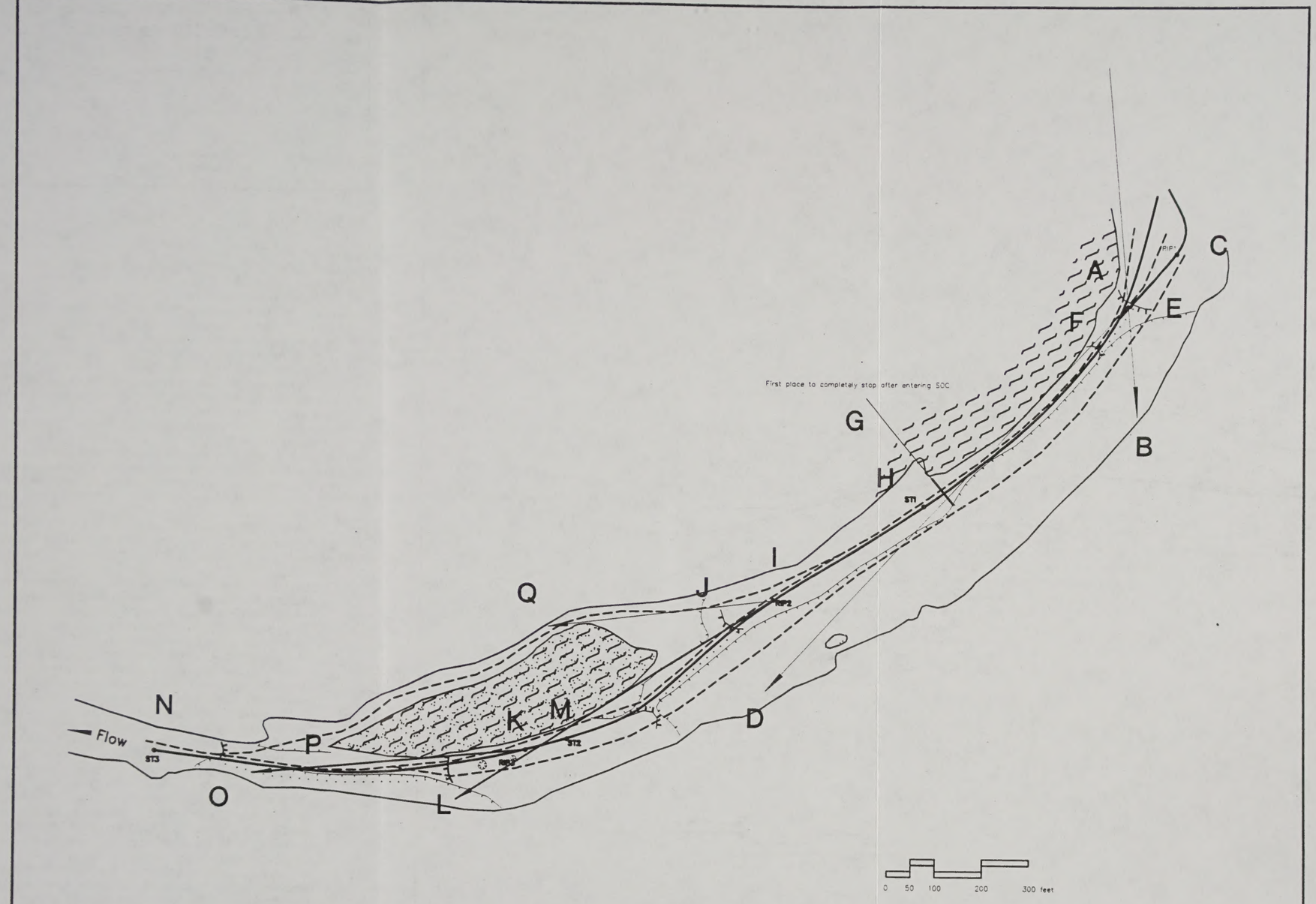
MTB Speed:

Other:

Rogue River Boating Safety and Conflicts Study
SOC Analysis

GOLD HILL RIFFLE
Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA



Downstream MTB Operation

Approach visibility: Point **A** and RIP1 at **C** are continuously visible from about 1000 ft. upstream of the RIP1 along LOS **B**; about 34 sec. at 20 mph to RIP1. From RIP1, visibility into the SOC is along LOS **D**. FC would have to float the 500 ft. from LOS **B** to LOS **D** in 34 sec. (14.7 ft/sec.) to be unseen from both the approach visibility point and from RIP1. All FC would be slower than 15 ft/sec.; RIP1 is the critical visibility point.

RIP: There are 2 internal stopping points and 3 RIPs. The last MTB stopping point before entering the SOC is at **E**; they can come off-plane at **F** and drift to **G** and stop by ST1 at **H**. RIP2 is at **I** and RIP 3 is at **K**. RIP1 is set 138 ft. above **E** to accommodate footprint, reaction time, and PSDs in a wide set-down area, RIP2 is set 100 ft. above **J** to accommodate the footprint and PDS, and RIP3 is set 163 ft. above **L** to accommodate footprint, reaction time, and PSD in a narrow set-down area.

ST: ST1 at **H** is set 50 ft. below the first place the set-down area is wide enough to allow a drifting MTB to stop by turning around and accommodates footprint and safe craft separation. ST2 and 3 are set 138 ft. below the respective set-down thresholds to accommodate PSD and safe craft separation.

PNS: Of the SOC from RIP1 to ST3 (2575 ft.), 1950 ft. is unseen (LOS **D** to ST3): The PNS is 0.757.

PSR: Safety risk is a result of several through-run situations and a pop-out situation:

Through-run #1; If FC are located below LOS **D** when the MTB passes RIP1 they could be overtaken before reaching ST1; about 32% of the FC follow the RR route to ST1. The MTB operating time to ST1 is 13.8 sec. on-plane from RIP1 to a point 138 ft. below the set-down threshold at **F** (403 ft. @ 20 mph), and 39.4 sec. to drift the 315 ft. to ST1 at 8 ft/sec. a total run time of 53.2 sec. Any FC unseen between LOS **D** and ST1 when the MTB passes RIP1 would need to float at greater than 2.3 ft/sec. over the 125 ft. from LOS **D** to ST1 in 53.2 sec. to avoid a MO. FC float speed information from the Hellgate SR indicates that all but the very slowest FC should float past ST1 before the MTB arrives. The safety risk for this situation is very low.

Through-run #2; If FC are located below LOS **O** when the MTB passes RIP3 they could be overtaken before reaching ST3; 92% of the FC use the RL route. The MTB run time to ST3 is 27.3 sec. (800 ft. @ 20 mph). FC would need to float at greater than 11.5 ft/sec. to float the 315 ft. from LOS **O** to ST3 in 27.3 sec. to avoid a MO. FC float speed information from the Hellgate SR indicates that in this type of hydraulic situation only the fastest 10% of the FC may have speeds great enough to avoid a MO.

Pop-out; FC that use the RR channel around the island can pop-out into the path of MTBs at point **P** at any time. Because the top of the FC route past the island is visible to MTB operators along LOS **Q** it is considered a time-dependent pop-out but due to very slow FC speeds on the RR route the FC encountered at **P** could occur on any MTB run unless the MTB stops for a protracted period above **L**. Only about 8% of the FC use the RR route but all are subject to pop-out risks at **P**.

Through-run risk #1 could be avoided with a very short (<20 sec.) delay at RIP1. Through-run risk #2 could also be avoided with an additional MTB await time. The MTB run time from RIP3 to ST3 is 27.3 sec. and assuming that the slowest FC float speed is 4 ft/sec. in this hydraulic situation a slow FC would float about 109 ft. below LOS **O** leaving about 206 ft. of possible MO area. At 4 ft/sec. FC could float the 206 ft. in 51.5 sec. Through-run risk #2 could be avoided if the MTB turns around in the set-down area at **M** and waits for about 52 sec. before proceeding past RIP3. The pop-out risk could be eliminated with a MTB wait in area **I** or **M**. If the typical slow FC along the RR route for the 600 ft. from LOS **Q** to **P** is 2 ft/sec. (300 sec.) and the FC speed for the 325 ft. from **P** to ST3 is 4 ft/sec. (81 sec.) the total float time for slower FC is about 381 sec. A MTB wait in the set-down areas of **I** or **M** of about 6.3 min. would eliminate the pop-out risks.

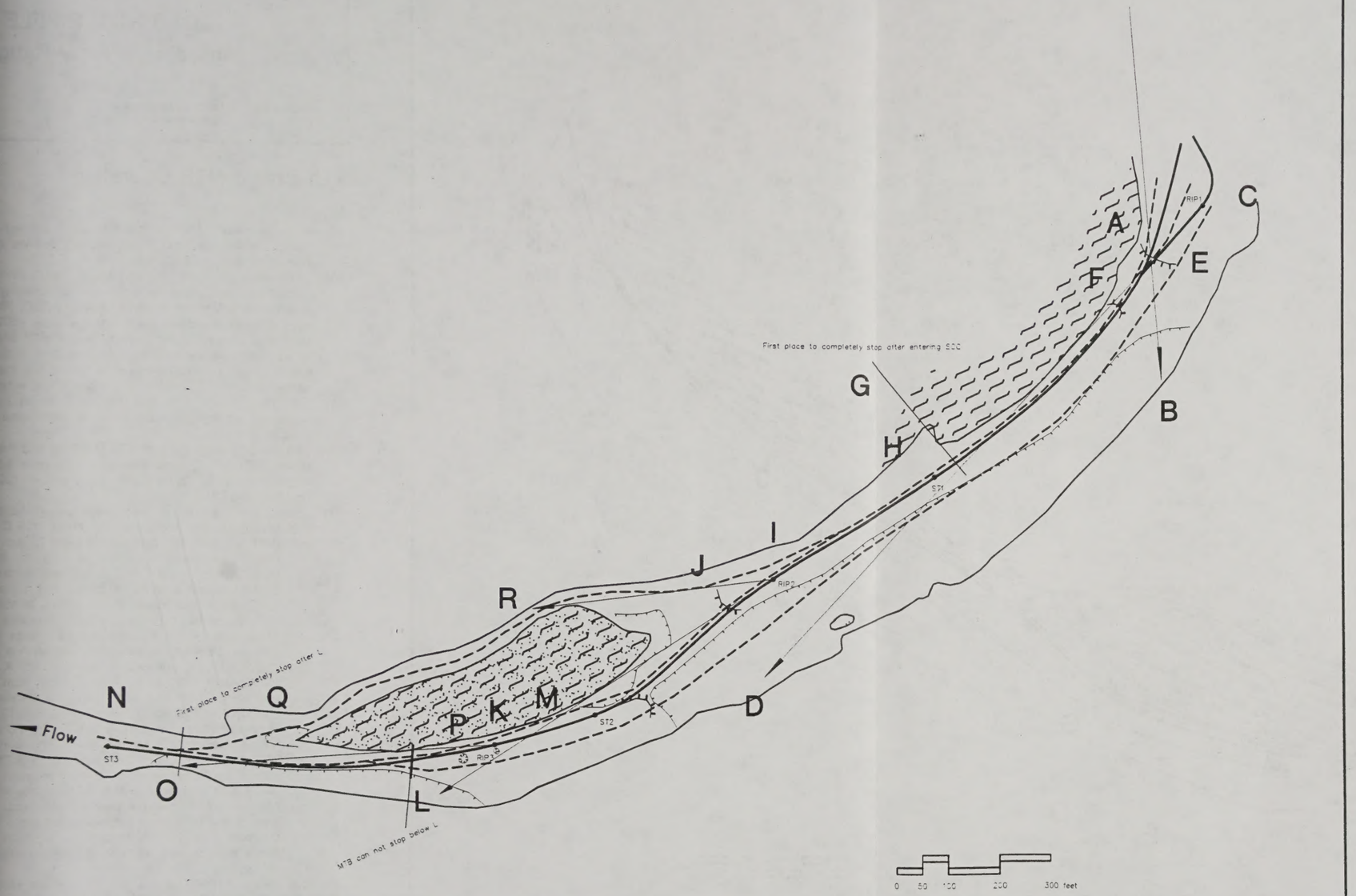
Assumptions:

Source

Slow FC Speed:
Ave FC Speed:
Fast FC Speed:

MTB Speed:

Other:



Assumptions: Source

Slow FC Speed:

Ave FC Speed:

Fast FC Speed:

MTB Speed:

Other:

Rogue River Boating Safety and Conflicts Study
SOC Analysis

GOLD HILL RIFFLE
High Flow Range

Prepared by: WRC-Environmental
Sacramento, CA

Downstream MTB Operation

Approach visibility: Point **A** and RIP1 at **C** are continuously visible from about 1000 ft. upstream of the RIP1 along LOS **B**; about 34 sec. at 20 mph to RIP1. From RIP1, visibility into the SOC is along LOS **D**. FC would have to float the 500 ft. from LOS **B** to LOS **D** in 34 sec. (14.7 ft/sec.) to be unseen from both the approach visibility point and from RIP1. All FC would be slower than 15 ft/sec.; RIP1 is the critical visibility point.

RIP: There are 2 internal stopping points and 3 RIPs. The last MTB stopping point before entering the SOC is at **E**; they can come off-plane at **E** and drift to **G** and stop by ST1 at **H**. RIP2 is at **I** and RIP 3 is at **K**. RIP1 is set 138 ft. above **E** to accommodate footprint, reaction time, and PSDs in a wide set-down area, RIP2 is set 100 ft. above **J** to accommodate the footprint and PDS, and RIP3 is set 163 ft. above **L** the last point to stop a MTB before having to drift or run on-plane ST3 to accommodate footprint, reaction time, and PSD in a narrow set-down area.

ST: ST1 at **H** is set 50 ft. below the first place the set-down area is wide enough to allow a drifting MTB to stop by turning around and accommodates footprint and safe craft separation. ST2 is set 50 ft below the set-down threshold to accommodate a drifting MTB footprint and safe craft separation. ST3 is set 138 ft. below the set-down thresholds to accommodate PSD and safe craft separation.

PNS: Of the SOC from RIP1 to ST3 (2575 ft.), 1950 ft. is unseen (LOS **D** to ST3): The PNS is 0.757.

PSR: Safety risk is a result of several through-run situations and a pop-out situation:

Through-run #1; If FC are located below LOS **D** when the MTB passed RIP1 they could be overtaken before reaching ST1; about 32% of the FC use the RR route to ST1. The MTB operating time to ST1 is 13.8 sec. on-plane from RIP1 to a point 138 ft. below the set-down threshold at **F** (403 ft. @ 20 mph), and 39.4 sec. to drift the 315 ft. to ST1 at 8 ft/sec. a total run time of 53.2 sec. Any FC unseen between LOS **D** and ST1 when the MTB passes RIP1 would need to float at greater than 2.3 ft/sec. to the 125 ft. from LOS **D** to ST1 in 53.2 sec. to avoid a MO. FC float speed information from the Hellgate SR indicates that all but the very slowest FC should float past ST1 before the MTB arrives. The safety risk for this situation is very low.

Through-run #2; If FC are located below LOS **O** when the MTB passes RIP3 they could be overtaken before reaching ST3; about 92% of the FC use the RL route. At point **P** ST3 is visible and if FC are observed the MTB can stop to drift. The run time from RIP3 at ST3 is 7.3 sec. on-plane from RIP3 to a point 138 ft. below **P** (213 ft.) @ 20 mph, and 55.7 sec. for the 557 ft. to ST3 assuming a MTB drift speed of 10 ft/sec.; a total of about 63 sec. FC would need to float at greater than 4.4 ft/sec. to float the 280 ft. from LOS **O** to ST3 in 63 sec. to avoid a MO. FC float speed information from the Hellgate SR indicates that in this type of hydraulic situation only the slowest 10% of the FC may have speeds too low to avoid a MO.

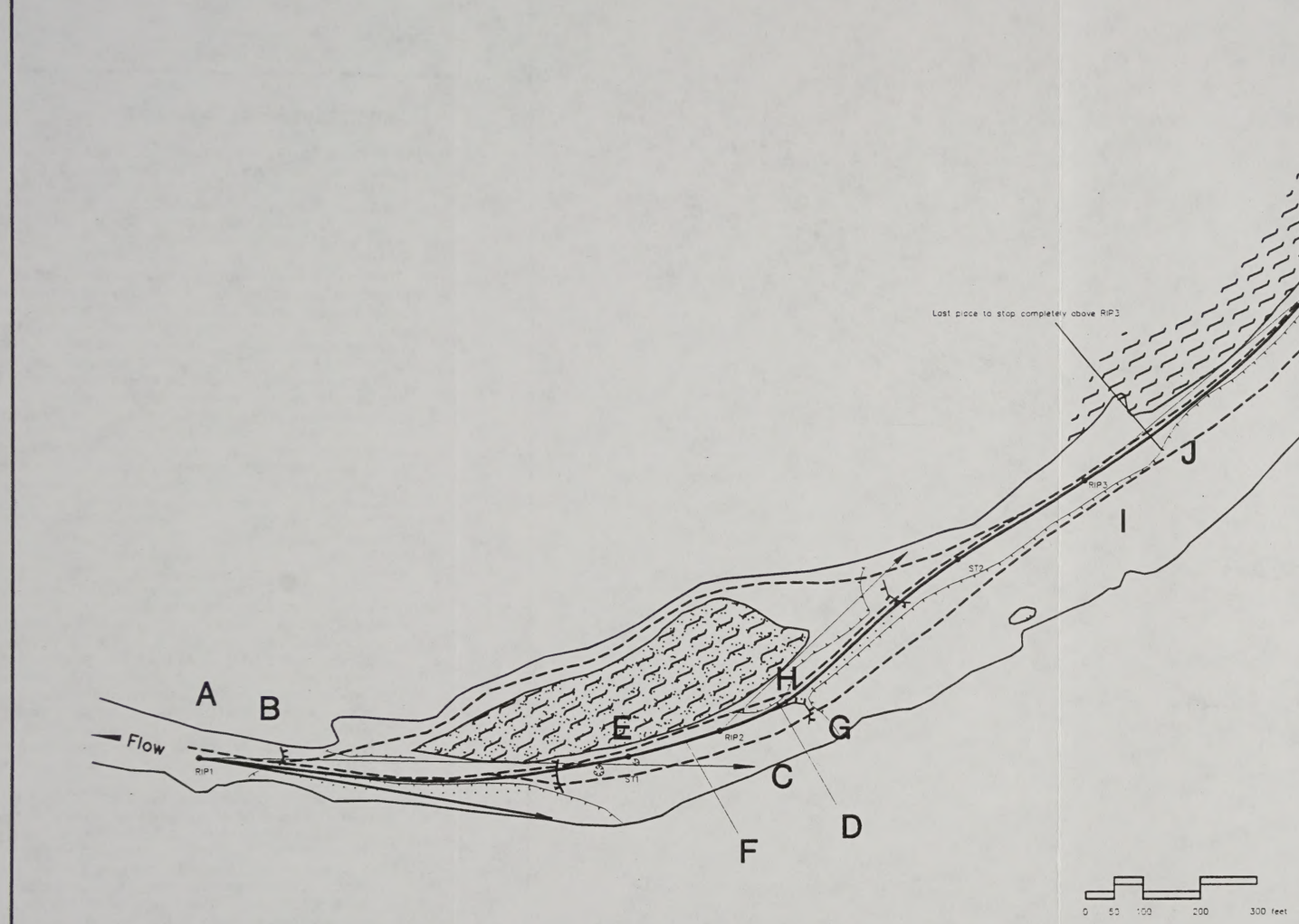
Pop-out; FC that use the RR channel around the island can pop-out into the path of MTBs at point **Q** at any time. Because the top of the FC route past the island is visible to MTB operators along LOS **R** it is considered a time-dependent pop-out but due to very slow FC speeds on the RR route the FC encountered at **Q** could occur on any MTB run unless the MTB stops for a protracted period above **I**. Only about 8% of the FC use the RR route but all are subject to pop-out risks at **Q**.

Through-run risks #1 and #2 could be avoided with a very short 9<20 sec.) delay at RIP1 and RIP3 respectively. The pop-out risk could be eliminated with a MTB wait in area **I** or **M**. If the typical slow FC along the RR route for the 600 ft. from LOS **R** to **Q** is 2 ft/sec. (300 sec.) and the FC speed for the 325 ft. from **Q** to ST3 is 4 ft/sec. (81 sec.) the total float time for slower FC is about 381 sec. A MTB wait in the set-down areas of **I** or **M** of about 6.3 min. would eliminate the pop-out risks.

Rogue River Boating Safety and Conflicts Study
SOC Analysis

GOLD HILL RIFFLE
High & Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA



Upstream MTB Operation

Approach visibility: RIP1 at point **A** and the lower portion of the SOC is visible from about 1400 ft. below RIP1 but the critical visibility point is from RIP1 along LOS **C**.

RIP: There are 2 internal stopping points and 3 RIPs. RIP1 is set 138 ft. below the last stopping point before entering the SOC at **B** to accommodate footprint, reaction time, and PSD; RIP2 is set 100 ft. below point **H** to accommodate the footprint and the PSD; and, RIP3, point **I**, is set 138 ft. below the last place to stop a MTB and avoid a MO (point **J**) to accommodate footprint, reaction time, and PDS. At high flows MTBs can set-down and stop between **B** and **E** but the area is too swift and narrow to allow FC float-bys of stopped MTBs without a MO situation.

ST: ST1 (at point **E**), ST2, and ST3 (at point **M**) are set 125 ft. past the respective set-down thresholds to accommodate PSD and safe craft separation.

PNS: Of the SOC from RIP1 to ST3 (2590 ft.) and the additional safety area above ST3 (125 ft.; see through-run situation #2 below), a total SOC length of 2715 ft., 75.1% (2040 ft.) is unseen (LOS **C** to ST3+point **L**). The PNS is 0.751.

PSR: Safety risk is a result of two through-run situations:

Through-run #1; FC are located just above LOS **C** when the MTB passes RIP1 and float past ST1 during the MTB run. The MTB run to ST1 (790 ft.) would require 27 sec. at 20 mph. In 27 sec. a typical fast FC (10 ft/sec.) could float 270 ft. downstream from point **D** to ST1 at **E** and a typical slow FC (4 ft/sec.) 108 ft. from point **F** downstream to ST1. All FC between **F** and LOS **C** at the time the MTB passes RIP1 would be involved in a MO; this area is 6.8% of the SOC. About 92% of the FC use the RL routes past the island. The minimum PSR for this through-run situation is (.920)X(.068)=.063.

Through-run #2; FC are located between LOS **K** and point **L** when the MTB passes RIP3 at **I**. The MTB run from RIP3 to ST3 (850 ft.) would require 29 sec. at 20 mph. In 29 sec. a typical fast FC (8 ft/sec.) could float 232 ft. from point **L** to ST3 and a typical slow FC (3 ft/sec.) 87 ft. from point **N** to ST3. All FC from LOS **K** to point **N** will be involved in a MO situation. The length of channel between LOS **K** and point **N** is 251 feet; this is 9.7% of the SOC. About 30% of the FC follow the MTB route between the set-down threshold below ST3 and point **I** and 100% of the FC use the MTB route between point **N** and the set-down threshold. The weighted FC use level of the MTB route between point **I** and **N** is about 44%. The minimum PSR for this through-run situation is (.440)X(.097)=.043. Above point **N** faster FC over a greater portion of the channel could be involved in a MO.

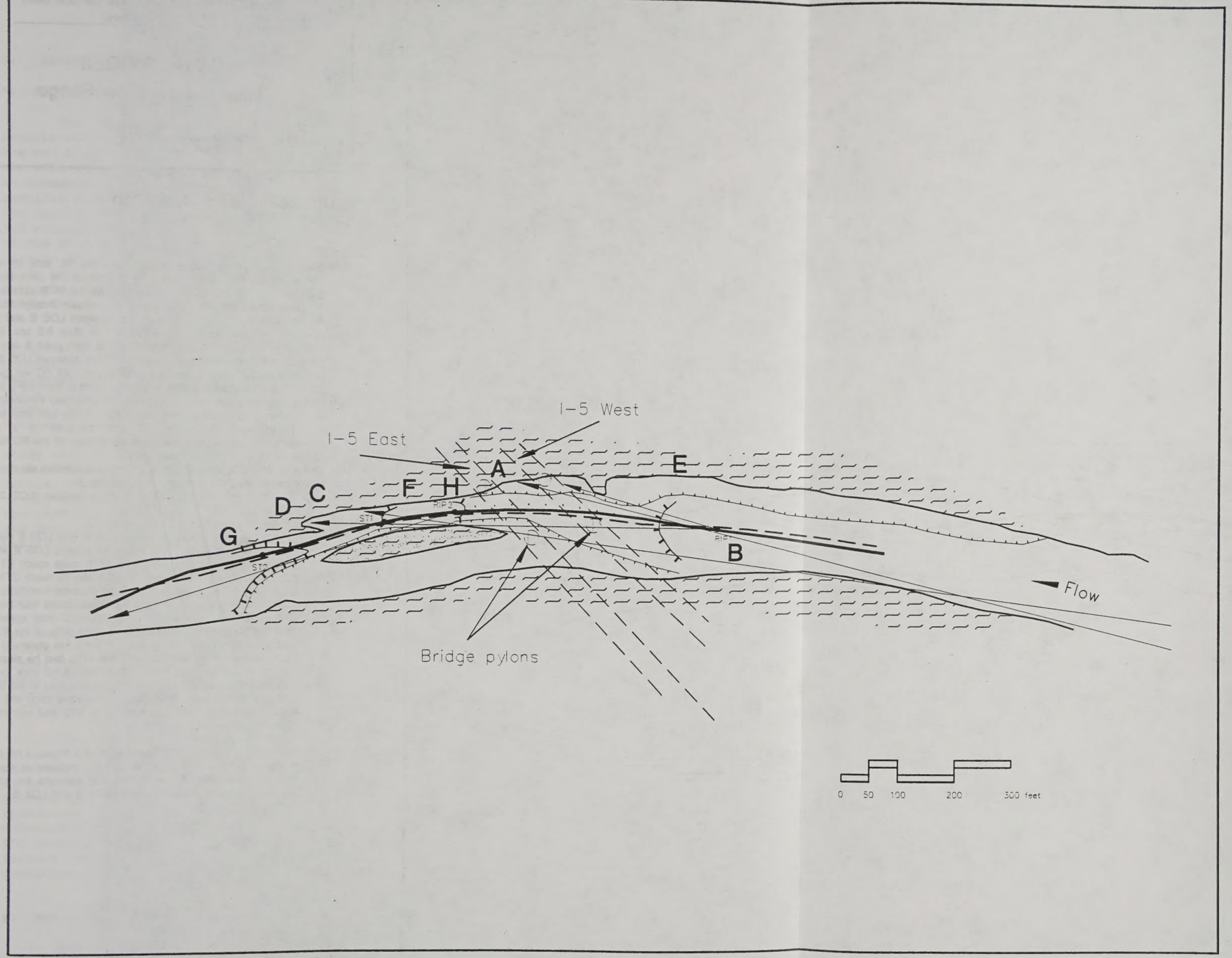
The total minimum PSR for the two through-run situations and the float-in situation is (.063)+(.043)=.106.

Assumptions: Source

Slow FC Speed:
Ave FC Speed:
Fast FC Speed:

MTB Speed:

Other:



Rogue River Boating Safety and Conflicts Study
SOC Analysis

TWIN BRIDGES
High & Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA

Downstream MTB Operation

Approach visibility: Point **A** and the RIP1 at **B** are continuously visible from about 1800 ft. upstream of the RIP1; about 59 sec. at 20 mph to RIP1. Point **C** is continuously visible from about 1000 ft. upstream of RIP1; about 34 sec. at 20 mph to RIP1. From RIP1, visibility into the SOC is along LOS **D**. FC would have to float the 560 ft. from LOS **A** to LOS **D** in 59 sec. (9.5 ft/sec.) or float the 60 ft. from LOS **C** to LOS **D** in 34 sec. (1.8 ft/sec.) to be out of sight from RIP1. Therefore RIP1 is the critical visibility point for FC slower than 1.8 ft/sec. and the origin point of LOS **C**, 1000 ft. above RIP1, is the critical visibility point for all other FC.

RIP: The last MTB stopping point is at **E**; they can come off-plane at **F** and drift to the tailwater. RIP1 at **B** is set by a SSD of 100 ft. above the set-down threshold to accommodate reaction time, and PSD in a 'wide' set-down area.

ST: ST1 at is set by a SSD of 138 ft. below the set-down threshold to accommodate reaction time, PSD, and safe craft separation and ST2 is set 50 ft. below the set-down threshold to accommodate a drifting MTB footprint and safe craft separation.

PNS: Of the SOC from RIP1 to ST2 (820 ft.), 210 ft. is unseen (LOS **D** to ST2): The PNS is 0.256.

PSR: Safety risk is a result of a through-run situation:

Through-run; The FC at greatest risk are the slow FC (just faster than 1.8 ft/sec.) that are just below LOS **D** when the MTB is at RIP1. If the MTB run is initiated in this situation the MTB would reach RIP2 at **H** in 16.2 sec (475 ft. at 20 mph) and from there the operator have complete visibility past the ST2. If FC are observed from **H** the MTB can set-down to drift by ST1 and drift to ST2. This would take 4.8 sec. on-plane to ST1 (140 ft. at 20 mph) and 22 sec. to drift to ST2 (220 ft. at 1.5 times average FC float speed [assumed to be 10 ft/sec]); a total MTB run time of 43 sec. from RIP1 to ST2. If a FC was positioned just below LOS **D** when the MTB passes RIP1, it would have to float faster than 4.9 ft/sec. to float the 210 ft. from LOS **D** to the ST2 at **G** in 43 sec. to avoid a MO. This indicates that if approaching MTBs do not stop at RIP1 even when no FC are observed there is the possibility of overtaking FC that have float speeds between 1.8 and 4.8 ft/sec. between LOS **D** and ST2 at **G**. From the Hellgate SR in similar hydraulic situations the slowest 10-15% of the FC could be expected to have float speeds in this range.

Assuming a minimum FC float speed of 3 ft/sec. a MTB would have to wait for 20 sec. at RIP1, even when FC are unobserved, to avoid MOs. At 3 ft/sec. an unseen FC would float 129 ft. of the 210 ft. between LOS **D** and ST2 during the normal 43 sec. MTB run time (including drifting time) leaving 81 ft. of potential MO area. At 3 ft/sec. FC would float the 81 ft. in 27 sec. A 27 sec. delay in run initiation could eliminate this MO situation.

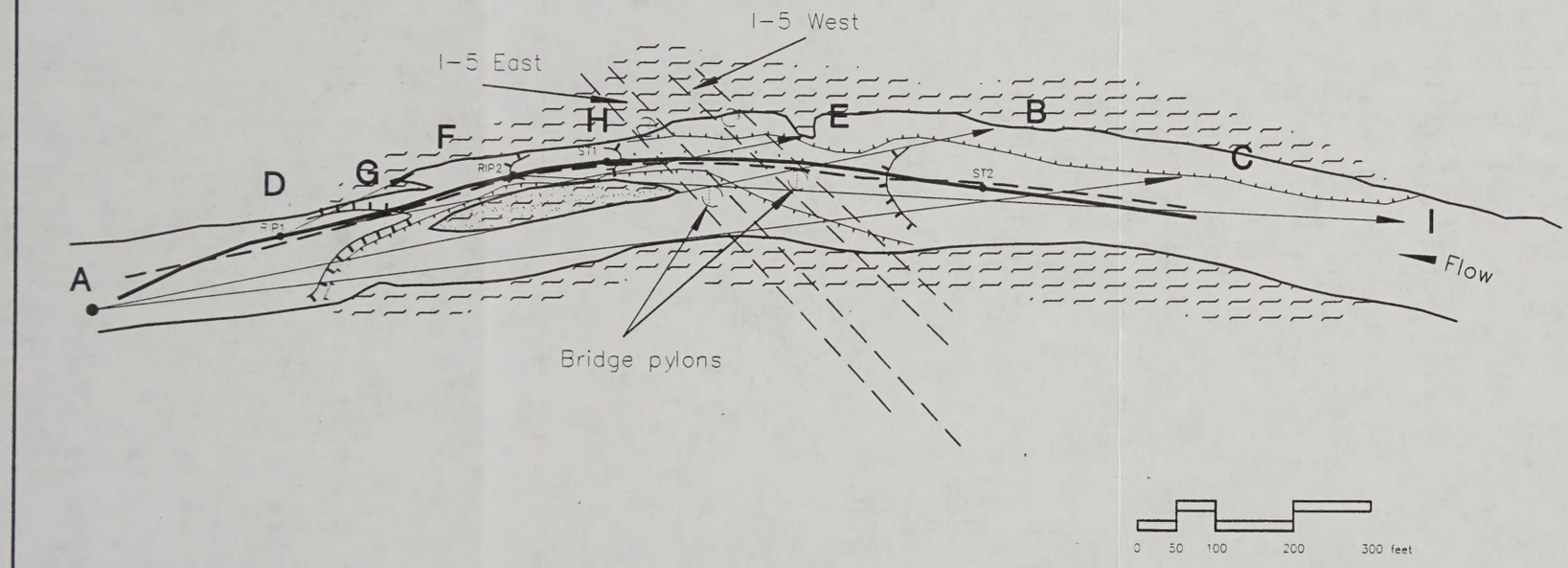
Assumptions:

	Source
Slow FC Speed:	
Ave FC Speed:	
Fast FC Speed:	
MTB Speed:	
Other:	

Rogue River Boating Safety and Conflicts Study
SOC Analysis

TWIN BRIDGES
High & Low Flow Range

Prepared by: WRC-Environmental
Sacramento, CA



Upstream MTB Operation

Approach visibility: MTBs approach from the RL side to enhance LOS conditions up the RL channel. From point **A** the area above the SOC between LOS **B** and LOS **C** is visible. As the MTB approaches RIP1 at **D**, views above the SOC project farther upstream through the **RL** channel. At the RIP1 the RR channel is visible between LOS **E** and LOS **F**. The on-plane run time from point **A** to RIP1 at **D** is 9.0 sec. (265 ft. at 20 mph). To remain unseen between LOS **B** from point **A** and LOS **E** from point **D**, a FC would have to float the 180 ft. between LOS **B** and LOS **E** in less then 9.0 sec.; a speed of 20.0 ft/sec. All FC will be slower than 20.0 ft/sec., therefore the critical visibility point is from RIP1 at **D**.

RIP: RIP1 and RIP2 are set 138 ft below the set-down threshold at **G** and **H** to accommodate reaction time and PSD. MTBs can stop between RIP2 and **H** to avoid in-floating FC and, because of a well defined tailwater/eddy pattern, can hold in areas outside of the FC float route and can avoid MOs in this set-down area.

ST: The ST1 and ST2 are set 125 ft. past the respective set-down thresholds to accommodate PSD and safe craft separation.

PNS: Of the SOC from RIP1 to ST2, 18.9% is unseen (LOS **D** to the ST). The PNS is 0.189.

PSR: Safety risk is a result of a through-run:

Through-run; FC are located between LOS **B** and LOS **E** during the MTB pass from point **A** to RIP1. If a FC passes LOS **E** after the MTB passes RIP1, to avoid a MO the MTB must reach ST1 before the FC does. The MTB will require 15.4 sec. to reach ST1 and be set-down (450 ft. at 20 mph). The float distance from LOS **E** to ST1 is 90 ft. and any FC faster than 5.8 ft/sec. could float from LOS **E** to ST1 in time to be involved in a MO. FC float speed information from the Hellgate SR indicates that about 50% of the FC could have float speeds greater than 6 ft/sec. If FC are observed by the MTB operator from RIP2 along LOS **I**, the MTB can be stopped between RIP2 and ST1 to avoid MOs. LOS **I** allows full view through to ST2 and the MTB can wait until no FC are observed in the SOC between ST1 and ST2 before proceeding. Therefore once the MTB passes RIP2 the operator can see through to ST2 and can avoid MOs by stopping before ST1.

Assuming a minimum FC float speed of 3 ft/sec., a **51 sec.** (180 ft. / 3 ft/sec. = 60 sec. - 9 sec. = 51 sec.) increase in the MTB transit time between point **A** and RIP1 would eliminate the probability that FC would remain unseen between LOS **B** and LOS **E**.

Assumptions: Source

Slow FC Speed:
Ave FC Speed:
Fast FC Speed:

MTB Speed:

Other:

V: SAFETY RISK/CONFLICT MODEL

A: Introduction

The Safety Risk/Conflict (SR/C) Model combines MTB itinerary schedules and the results of the SOC Assessment to develop estimates of potential safety risk and conflict. The two primary elements in the SR/C Model approach are: 1) an estimated number of FC that the MTBs may encounter at each SOC from the FC Use Distribution Model; and 2) from the SOC Assessments, the degree of safety risk and conflict that may result from encountering a specific number of FC at each SOC. As mentioned earlier, data collection limitations in the Gold Hill Study Reach prevented the development of a reliable FC Use Distribution Model and reliable SOC safety risk parameters. These limited data sets prevent the application of the SR/C Model to the Gold Hill Study Reach. This probability modeling approach can be used in the future if additional data collection efforts are undertaken on the Gold Hill Study Reach such that reliable FC use and SOC safety risk parameters are developed. The following discussion involves the SR/C Model as it was developed for the Rogue River BS/C Study and applied to the Hellgate Study Reach.

The SR/C Model is a spreadsheet designed to convert the Probability of Mutual Occupation (PMO) at specific SOCs for specific MTB runs into total expected Mutual Occupation incidents (MOs) for a variety of recreational conditions and recreation management scenarios. It was designed to provide the basis for comparative evaluations of the safety risk and conflict implications for these various conditions and scenarios. The primary basis for comparing the relative safety risks is the estimated number of MO incidents over the duration of the main part of the recreation season; estimated MOs for a specific set of circumstances serve as a relative measure of safety risk exposure. In the study area this Main Recreation Season (MRS) is from late May to early September. It is a period with consistent MTB trip itinerary schedules and similar FC user activities, use levels, and daily spatial and temporal use patterns. While MTBs are in use in those parts of May and September outside of the MRS, these periods are excluded from consideration in the SR/C Model because MTB schedules are different due to daylight limitations, MTB trips are more sporadic due to variable demand, FC use activities shift toward angling, and FC use levels are sharply lower.

An important aspect of the SR/C Model is that it has both a low flow and a high flow component. These flow level components are used to estimate safety risk and conflicts at SOCs based on the differing low and high flow channel/hydraulic conditions identified in the SOC Assessments (Chapter IV). In the SR/C Model these low and high flow conditions are not assigned to specific flow ranges. They simply reflect the identified variability of safety risks and conflicts associated with some lower more risky flow condition and some higher less risky flow condition. The assignment of a streamflow magnitude that separates these safety risk related flow conditions can be set at any flow level desired should it be a factor in evaluating safety risk and conflicts for a specific MRS flow regime with differing daily flows.

The SR/C Model can be used to determine baseline MRS MOs for a specific MTB use pattern, specific FC use level, and specific recreation management scenarios. This baseline MRS MO estimate can be used to determine the safety risk and conflict implications of modified conditions. Modified conditions can include MTB trip numbers, MTB trip itineraries, MTB trip schedules, FC user numbers, daily MTB closures, and variety of SOC characteristics. All of these modifications, except the SOC characteristics, can be easily undertaken with minor SR/C Model adjustments. Changes in SOC characteristics require new SOC Assessments. Modifications that would require new SOC Assessments include among other factors, different MTB operational characteristics (PSDs, etc.), changed channel bed conditions, changed line of sight conditions, and changed FC use patterns in the SOCs.

B: MTB Itinerary

The SR/C Model is operationally based and selects the PMO at each SOC from the expected MTB time of arrival and the expected FC use levels. The expected MTB time of arrival is determined by routing a MTB trip through its entire itinerary schedule and identifying the 15-minute interval in which it would run through each SOC in each direction. The FC Use Distribution Model is then used to estimate the number of FC encountered at each SOC. In this BS/C Study a single "MTB trip" includes 1 to 7 individual MTB craft on a specific schedule and itinerary such as AM Whitewater, PM Scenic, Dinner, and Brunch trips, etc.

The MTB itinerary schedules used in the BS/C Study were developed using transit times/schedules to intermittent locations along the MTB routes obtained from the MTB operator member of the FG. Schedules included trip start times from the dock in Grants Pass, approximate times to the turn around points at Zigzag Creek or Grave Creek, and times to/from intermittent stopping locations at OK Corral and Galice. These itinerary schedules were plotted by river mile assuming a straight line transit between each location accounting for any scheduled stops such as lunch, brunch, and dinner (See Figure 31). Some of these itinerary schedules were slightly modified based upon field observations by WRC.

These plots of MTB trip itinerary schedules allow the arrival time of MTBs at each SOC to be predicted. Each different MTB trip itinerary schedule should result in different PMOs at the same SOC because they arrive at the SOC at different times of the day and encounter different numbers of FC. When considering the entire MTB trip itinerary schedule through all the SOCs on the itinerary, each trip schedule will have different total MO estimates because each runs through different SOCs at different times of the day. These variations are in addition to differences resulting from operating at either different total daily or seasonal FC use levels or different flow levels.

C: SR/C Model Products

For each model run that uses a given MTB itinerary schedule, flow conditions, FC use level, and SOC characteristics, the SR/C Model develops two general products: 1) an Individual MTB Trip Safety Risk Index; and 2) a Seasonal Safety Risk Index.

1) Individual MTB Trip Safety Risk Index:

One product of the SR/C Model addresses the safety risk exposure attributes of specific MTB trip itinerary schedules and develops a single numerical trip safety index that allows comparisons between MTB trip itinerary schedules and modified schedules.

Figure 32 is an example product of a single MTB trip itinerary schedule safety risk analysis and the development of the trip safety risk index; this example is for a weekend AM Whitewater trip under low flow conditions, and 1992 use levels and user patterns. The top cell in the figure shows the assumed trip schedule throughout its itinerary and the estimated FC that will be encountered at the various SOCs. The estimated FC numbers are generated by the FC Use Distribution Model. The expected FC curve shows that the MTB trip encounters the highest numbers of FC on the upstream leg, from Argo through Hog Creek Islands, after the it turns around at Grave Creek (The SOCs are identified by RM location, see Chapter II, section B: 6). The bottom cell of the figure shows the PMOs that are predicted to result from encountering the expected number of FC at the various SOCs. For this trip itinerary schedule the three SOCs with the greatest predicted PMOs are, in descending order, the upstream runs of Lower Galice Chute, Upper Galice Chute, and Bailey Riffle. This figure shows that the greatest PMOs occur at the SOCs from Argo through Brushy Chute on the upstream leg.

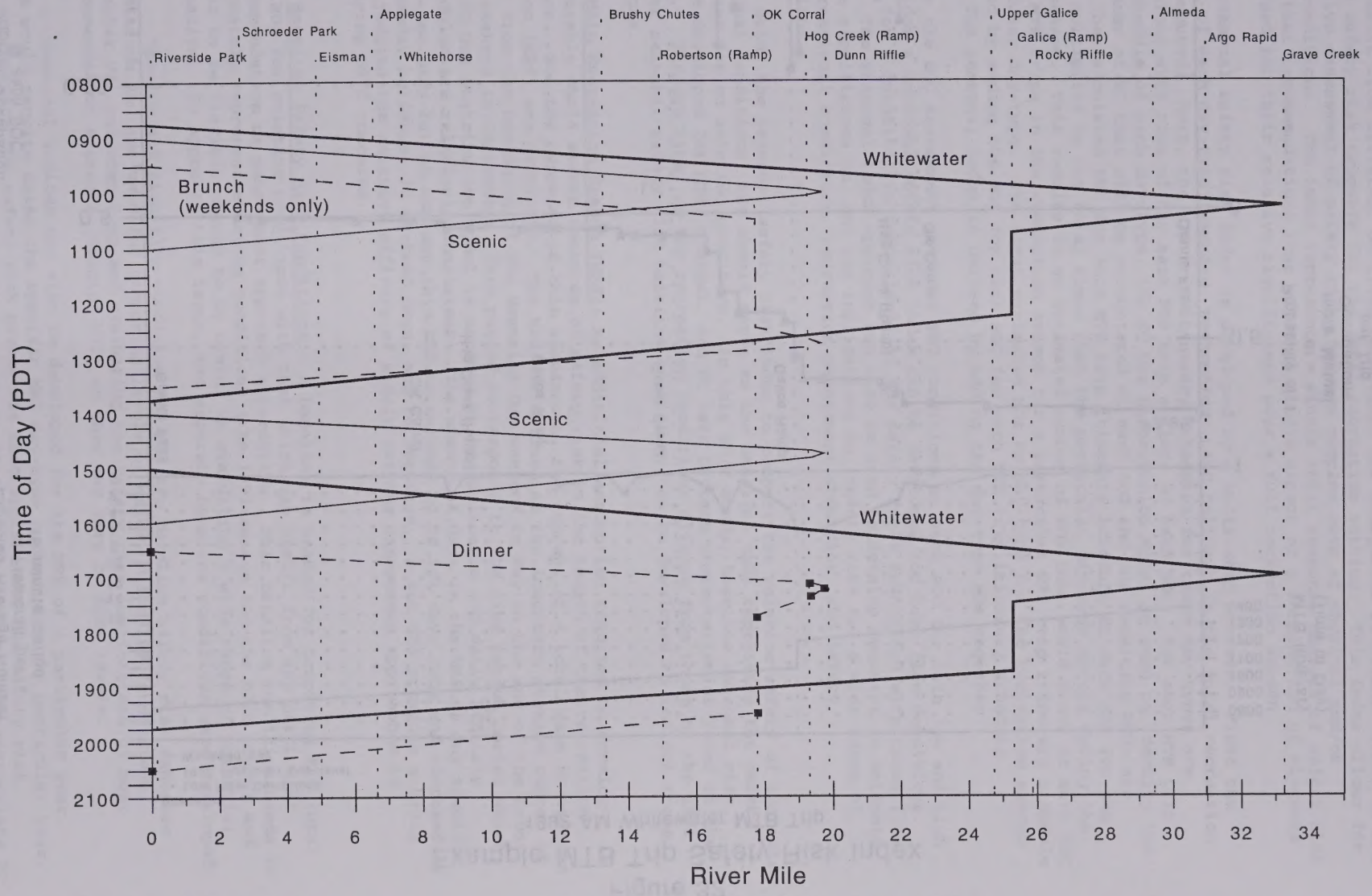
The center cell of Figure 32 shows a plot of the accumulating probability of 1 or more MO incidents through the trip itinerary. Each step in this plot reflects the accumulating probability of at least 1 MO occurring as the MTB trip progresses. The points on this plot are created by the inverse of the product of all the probabilities for a safe run through each and every SOC to that point on the itinerary. The graphic steps in this plot show that the portion of this MTB trip itinerary schedule with the greatest accumulation of safety risk exposure is on the upstream leg from Argo Riffle through Upper Galice Chute. For the AM Whitewater trip itinerary schedule the final probability of 1 or more MO incidents for the whole trip is .779, or a 77.9% chance. This means that on a long term average, for the modeled conditions, there is about a 78% chance that at least 1 MO incident will occur on each trip. This is at least 1 MO incident on the AM Whitewater itinerary schedule on about 4 out of every 5 trips.

This SR/C Model product allows each MTB trip itinerary schedule to be evaluated for total potential safety risk exposure, to identify the portions of the itinerary that are most significant to accumulated safety risks, and to track the FC use level and SOC PMO sources of the accumulating safety risks. Modified MTB schedules can be used to problem solve for possible trip itinerary schedule adjustments that may result in reduced safety risks. The MTB trip itinerary schedule safety risk index and the graphic plots of accumulating risk allow the direct comparisons of the safety risk attributes of the various MTB trip itinerary schedules.

Figure 31

1992 MTB Itinerary Schedule

Hellgate Study Area - MRS



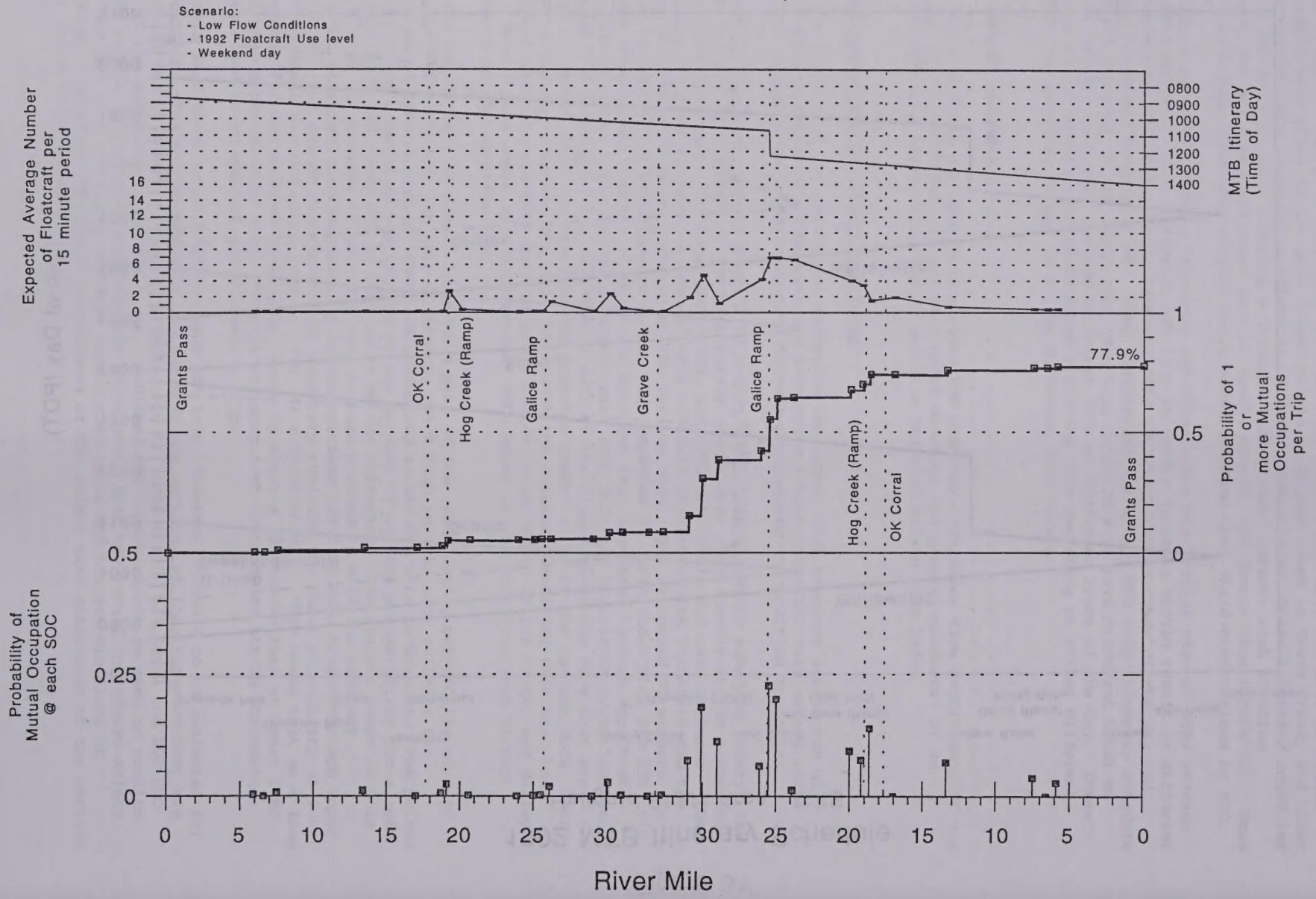
(Itin. info J. Baumer, Hellgate Ex.)

(Downstream from 6th Street Bridge - Grants Pass)

Figure 32

Example MTB Trip Safety Risk Index

1992 AM Whitewater MTB Trip



2) Seasonal Safety Risk Index:

A single measure or index was also developed to compare the relative safety risks that would result from different on-river conditions and management scenarios, etc., on the basis of the safety risk exposure for the total recreation setting. This index allows for the comparative assessment of safety risks between complex sets of physical and/or management conditions. The index represents a single total seasonal measure of safety risk exposure so that recommendations that effect a single aspect or a combination of elements can be assessed for their relative significance over a full recreation season.

The seasonal safety risk index is developed by a multi-step process. First the total number of each day-type (weekday, weekend day, and holiday) in the total recreation season is computed. Next, the MTB trip itinerary schedules for these day-types are identified along with time of day each MTB trip arrives at each SOC. For each MTB trip itinerary schedule of each day-type, the FC Use Distribution Model is used to identify the expected number of FC that will be encountered at each SOC and the resulting PMOs are estimated. The calculated PMO for each MTB trip itinerary schedule at each SOC for the day-type is multiplied by the total times that the particular day-type occurs during the recreation season. This results in an estimated number of MOs that would occur at each SOC for all the MTB trips in the recreation season for a particular MTB trip itinerary schedule for a particular day-type. The total estimated MOs by day-type for the recreation season is calculated by adding the MOs for each SOC for each MTB trip itinerary schedule itinerary. The seasonal index is derived by adding the day-type MOs together.

Since the SOC Assessment includes PMO conditions at each SOC for both low and high flow conditions a seasonal safety risk index can be developed for both flow conditions. This allows for a quantitative comparisons of the safety risks associated with these flow conditions. The seasonal index approach can also be used to develop measures to estimate the relative significance on, and the implications to, safety risk for a wide range of changed recreational conditions, recreation management scenarios, and safety recommendations.

When using the seasonal safety risk index to compare the relative safety of two sets of recreational conditions, one should serve as the baseline that represents the safety risk estimates for an existing condition. In this BS/C Study, baseline seasonal risk indexes were developed for MTB, channel, and FC user pattern characteristics found in the 1992 season. Through time, as the recreation conditions diverge from those of the 1992 season, other seasonal safety risk baseline conditions can be developed to reflect those new conditions.

a) Main Recreation Season (MRS); An additional assumption required to develop comparable whole season measures of safety risk is the length of the recreation season. For the purposes of this assessment, the concept of a total Main Recreation Season (MRS) was developed. The MRS was defined as the long-term average number of days from the beginning of the Memorial Day weekend in May to the end of the Labor Day weekend in September. This period corresponds to the time period during which the FC Use Distribution model is assumed to be applicable and daily MTB trip schedules are relatively consistent. The number of days in the MRS of any specific year can vary but on average this MRS is assumed to be 101 days long and composed of 3 weekday holidays, 30 weekend days, and 68 weekdays. A set MRS provides a basis for judging the relative efficacy of widely varying management approaches to reducing BS/C concerns.

b) Baseline Safety Risk Conditions; A baseline is needed for comparing the total MRS MOs for existing conditions with that which may result from any particular recommendation or management approach alternative. This baseline condition needs to adequately represent existing conditions (the 1992 season for the BS/C Study) and needs to be flexible enough to be useful in evaluating a wide range of potential scenarios. To approach this issue, two separate baseline conditions were developed.

The low and high flow condition MRS MOs are baseline safety risk exposure conditions and are used for comparing levels of safety risks 1992 conditions (Chapter VI) and comparing and evaluating the safety risk implications of most recommendation elements (Chapter VII) as they may vary by flow levels.

Seasonal indices can also be developed for the MRS of a particular year. This would require using the specific MRS day-type numbers for the particular year, the appropriate SOC safety risk parameters that approximate the safety risk conditions for each of the SOC/scenarios in that particular year, the appropriate FC use levels, a prescribed streamflow magnitude that separates low and high flow

safety risk conditions, the assignment of low and high flow conditions to specific dates through the MRS, and the actual MTB trip itinerary schedule used in that year as it may have been influenced by passenger demand and/or flow related itinerary adjustments.

i) Low Flow Condition Baseline; total expected MRS MOs using the 1992 FC use levels and daily use patterns, 1992 MTB trip itinerary schedule, and the resulting SOC PMOs for low flow conditions throughout an average MRS (101 days). The resulting low flow condition baseline for the Hellgate Study Reach was 316 MRS MOs.

ii) High Flow Condition Baseline; total expected MRS MOs using the 1992 FC use levels and daily use patterns, 1992 MTB itinerary schedule, and the resulting SOC PMOs for high flow conditions throughout an average MRS (101 days). The resulting high flow condition baseline for the Hellgate Study Reach was 244 MRS MOs.

For a detailed review of MRS MOs by SOC, study reach section, and MTB trip itinerary schedule refer to Chapter VI. B: 3) and Table 5.

D: SR/C Model Limitations

As has been explained earlier, the SR/C Model estimates safety risk exposure by the "inadvertent risk" associated with MTBs proceeding into SOCs and unexpectedly encountering FC traffic in areas with limited operational options. This definition was premised by the basic assessment assumptions that a MTB operator always uses the most prudent judgement, best skill, and given the opportunity, will always choose to avoid conflicts with FC and other river recreationists. This conservative basic safety risk assumption is one of many used in the SOC Assessment, FC Use Distribution model, and supporting BS/C study data. The precision and accuracy of the SR/C Model is limited by these assumptions and interpretation of model results should be made with the assumptions in mind. Examples of these assumptions that effect the precision and accuracy of the results are:

1) MTB Operations:

a) MTB operators will use the best judgement and skill while operating in the SOC; if possible a MTB operator will stop or set-down to drift to avoid, or reduce the potential outcome severity of a MO;

This assumption limits the quantity of safety risk predicted by the SR/C model to the "unavoidable" inadvertent risks under 1992 river conditions and management under perfect conditions. It assumes that in each and every situation MTB operators will always make and execute the decision that limits MOs based upon the visual information presented to the operators and operational alternatives. If in any SOC/scenario MTB operators exercise less than expert skill, or less than complete safety-prudent judgement (as was observed during the 1992 field season), more MOs will occur in the SOCs than those that result from the model run. These would be Overt MOs. If MTB operator skill and judgement problems occur in non-SOC areas (as was observed during the 1992 field season) Overt MOs could also occur which are not part of the Inadvertent MOs of the SOCs addressed by the BS/C Study.

If these overt safety risk issues are included the total MRS MOs (Inadvertent and Overt) could be much greater than the model outputs. This assumption results in minimum SR/C Model estimates of MO incidents.

b) Only the lead craft in each MTB trip creates the potential for safety risks at each SOC;

This assumption is based upon MTBs running in convoys with gaps between MTB craft small enough that any information communicated between MTB craft via radio will allow subsequent MTB operators to alter their behavior/runs and negate any potential MOs. This assumption applies to all MTB trips in the calculated MRS.

If substantial time gaps are created between individual MTB craft (such as Brunch and Dinner trips when 7 MTBs split into to 2 convoys of 5 and 2 MTBs each separated by 20-30 minutes), safety risk exposure will be greater than those calculated by the SR/C model and seasonal risk index. On-river observations indicate that gaps of 5 minutes or larger are large enough to degrade the reliability of radioed information and that MTBs trailing lead craft by more than 5

minutes should be considered as a new lead craft that may be involved in inadvertent safety risks and conflicts.

This assumption results in minimum MOs estimates and the Dinner trip MOs being more underestimated than other MTB trips.

2) MTB Stopping Distances:

a) The MTB SSDs are based upon stopping requirements developed from 1992 MTB stop tests on "Medium" size MTBs on the Lower Rogue River;

The PSDs of "Medium" sized MTBs are the basis of MTB SSDs which in turn is an important parameter controlling the PSRs and PMOs for each SOC/scenario. The PSDs of "Medium" sized MTBs were used to estimate the SSDs of "Medium" sized MTB in a variety of emergency stopping situations and scenarios. The basic "Medium" sized MTB PSDs were estimated from MTB stop tests conducted on the Lower Rogue River using MTBs similar to, but not the same as, the "Medium" sized MTBs used on the Hellgate Study Reach.

In spite of the overall size and capacity similarity , the tested MTBs have more engines and total horsepower than do the "Medium" sized MTBs on the Hellgate Study Reach and could have shorter PSDs. If the PSDs of the Hellgate "Medium" sized MTBs are longer the SSDs would also be longer. Longer SSDs would result in RIPs and STs being set farther from set-down thresholds, longer SOCs, greater PROs, more restrictive LOS limitations, fewer usable set-downs in SOCs, higher PNSs, and higher PSRs. This would generally result in higher PMOs for the SOC/scenarios and greater estimated MRS MOs.

Until PSDs of Hellgate "Medium" sized MTBs are confirmed by field tests this assumption could result in underestimated SOC safety risk parameters and underestimated MOs.

b) The SOC/scenario safety risk parameters and MOs estimates are based on the assumption that all MTB trip lead craft are "Medium" sized craft;

Many MTB trips in the Hellgate Study Reach are led by "Large" sized MTBs with different PSDs and SSDs from those assumed for "Medium" sized MTBs. To accurately portray the potential MOs on a specific MTB trip the PSDs and the SSDs of the lead craft would need to be used to develop all of the specific SOC/scenario safety risk parameters. This results in different SOC Assessment steps for each MTB that has a different PSD. It is likely that all the "Large" sized MTBs on the Hellgate Study Reach have longer PSDs than do the tested MTBs on the Lower Rogue River. Longer PSDs result in longer SSDs. Longer SSDs would result in RIPs and STs being set farther from set-down thresholds, longer SOCs, greater PROs, more restrictive LOS limitations, fewer usable set-downs in SOCs, higher PNSs, and higher PSRs. This would generally result in higher PMOs for the SOC/ scenarios and greater estimated MRS MOs. Although some "Small" sized MTBs are listed as in use on the Hellgate Study Reach (Table 1), none were seen on any of the MTB trips observed during the 1992 season, much less used as lead craft.

In order to use the modeling approaches developed in this BS/C Study to estimate MOs for the actual MTBs used in the study reach, stop tests need to be conducted on the MTBs actually used as lead craft and the PSDs and SSDs for each craft need to be established. For each set of MTB SSDs new SOC Assessments need to be executed and SOC/scenario PSRs and PMOs need to be estimated for each MTB craft type. Finally the specific MTB craft that is serving as a lead craft on a specific MTB trip itinerary schedule needs to be identified and the MTB-specific SOC safety risk parameters used to calculate PMOs and MOs.

This assumption leads to SR/C Model results that underestimate the MOs. The degree of underestimation is related to the degree to which PSDs of "Large" MTBs are longer that those of "Medium" MTBs, and proportion of MTB trips led by "Large" sized craft. Until specific SOC Assessments are conducted for these "Large" sized MTBs the power function of the relationship is unknown. The predominance of "Large" sized MTBs presently used as lead craft on the various MTB trips on the Scenic Section of the Hellgate Study Reach would result in greater trip and MRS MOs than are predicted by the SR/C Model. This assumption does not underestimate MOs for the Whitewater Section because no MTB trips are led by "Large" sized craft.

3) FC Use Distribution Model:

a) Predicted FC use is an average of observed FC use patterns;

The FC Use Distribution Model generates FC use number estimates for each 15-minute interval on the UUCs from a 3-point averaging of simple average information. While this running averaging approach develops a more reasonable long-term average estimate of FC likely to be encountered, actual FC use is more "spiky" than shown by the UUCs. The actual pattern of FC numbers that could be encountered by MTBs at SOCs is different. In general for actual MTB arrivals there will be a relatively large number or arrival incidents with zero FC and relatively few with very high FC numbers. The 3-point running average UUCs result in overestimation of the frequencies that arriving MTBs will encounter low, but not zero FC. Due to a variety of SOC Assessment elements, lower numbers of FC present at SOCs produce the highest PMOs.

It is difficult to estimate the changes in PMOs and MOs that would occur if a more "spiky" FC use pattern is used. The PMOs and MOs are a result of MTB operations, channel conditions, and FC use levels and the resultant change in PMO could lead to either increased or decreased MOs depending on the predominant direction of the skew relative to the PMO peak on the SOC/scenario SR/C Curves. Based on the shape of the PMO curves of the SR/C Curves and the skews of the 3-point running averages on the UUCs, generally MOs should be smaller than those resulting from the SR/C Model. Changes should be mostly for downstream MTB operational direction scenarios.

b) The FC Use Distribution Model was developed from a limited data set;

Even though access data from over 60 sample days were used in the development of the FC use pattern in the Hellgate Study Reach, the UUCs could be improved through a more thorough data collection process. Any UUCs developed from additional data would provide a more reliable estimate of FC use levels and hence more reliable PMO and MO estimates from the SR/C model. New and improved FC user distribution information could change the UUCs in any number of ways. These changes would result in different expected FC numbers at SOCs for any of the MTB trip itinerary schedules and would result in different PMOs and MOs.

4) SOC Assessment:

a) The SOC Assessments were conducted on map bases with variable scale accuracy;

The scales of the SOC Assessment plates were estimated using a variety of methods. On the Hellgate Study Reach the scales were developed through a process that included ground measurements and scaling with the low altitude near-vertical aerial photos, using the high altitude aerial photos and the USGS autoCAD topographic base maps. With this process the scale accuracy of the SOC Assessment plates should be fairly good with an error factor of probably much less than 5%. On the Gold Hill Study Reach less effort was expended on scale accuracy because the full risk probability modeling approach was not used. On that study reach it is possible that the SOC Assessment plate accuracy error factors could by greater than for the Hellgate Study Reach.

The SOC Assessment plate scale error factors could result in errors in estimated distances within various portions of the various SOCs. The SOC safety risk parameters are tightly controlled by distance parameters between specified locations and assumed MTB operational stopping distances. As a result the SOC Assessment results could be highly sensitive to map accuracy. Because of the scale checking process engaged in on the Hellgate Study Reach SOCs it is anticipated that scale errors are small, that the distance estimation errors that could have occurred were small, were not errors in one consistent direction, resulted in counteracting safety risk implications, and probably have little influence on safety risk parameters or MRS MO estimates. On the Gold Hill Study Reach the potential SOC Assessment plate scale errors are considered suspect enough that should a full SOC Assessment and SR/C Model approach be used in the future to address BS/C issues, the SOC Assessment plates should be checked for scale problem.

b) FC overlap relationships in SOCs were developed from a limited data base;

Even though SOC user patterns were observed on over 80 sample days on the Hellgate Study Reach, the actual number of FC groups filmed from locations that could confirm FC entry, overlap, and exit in the various SOCs were relatively limited. A total of about 120 FC groups were used to develop the overlap curves for all of the SOCs and the aggregate overlap curve on Figure 28. The number of FC group observations generally declined with increasing FC group size. Given the FC group size distribution and sampling frequency relationships, the reliability of the aggregate curve declines with increasing FC group size. The largest FC group in the data set are two groups of 18 FC. The correlation coefficient of the aggregate overlap curve is .736 which shows a fairly strong relationship between the curve and the data points up to about 20 FC. For groups larger than 20 FC the aggregate curve is an extension of the curve formula for FC groups less than 20 FC. Therefore the average FC overlap relationship up to about 20 FC could be considered as reasonably reliable for the FC groups observed but the curve could represent increasingly unreliable relationships as the FC group sizes increase between 20 and 50 FC.

The FC SOC overlap relationship was assumed to represent average conditions for all FC groups at each FC group size category. The relationship is used to estimate the probability that the SOC is occupied (PRO) and the probability that all of the FC are unseen (PNS) for any given FC use level. If real average overlap relationships are different than those developed from the 1992 field data, the SOC Assessment and SR/C Models will provide erroneous PMO and MO results. Errors could result in either underestimates or overestimates of safety risk at specific SOCs and for the study reach or individual sections.

With an improved and extended data base, the general reliability of the aggregate overlap curve can be improved and reliability can be extended to higher FC use levels. If enough FC group data is collected at each of the SOCs separate FC overlap relationships could be developed and used for each SOC in the SOC Assessment and SR/C Model runs.

c) Risk is calculated based upon one FC being in the hazard zone during an MTB run;

Even though the PRO and PI are calculated based upon variable numbers of FC being in the SOC when a MTB initiates a run at the RIP, the PSR (and resulting PMOs and MOs) is calculated based upon the probability that only one FC is in the potential safety risk situation. As an example for a particular potential MO situation of a SOC/scenario, the SOC Assessment results may conclude that for the recorded FC float speed distribution, a randomly located FC would have a PSR of .200; there is a 20% chance that the FC would not float to the ST in time to avoid a MO situation and an 80% chance (.800) that it would. However in multi-FC situations a MO is only avoided if all FC float past the ST. If there are 2 FC in the potential MO situation they each would have a .800 chance of floating to the ST in time and a .200 chance of not reaching the ST. Assuming that the speed and location of each FC are random, the probability that both FC will each the ST in time to avoid a MO is a product the probabilities of each reaching the ST multiplied together and subtracted from 1. In this case the PSR would be .800X.800-1 = .360. Increasing the FC occupation of the hazardous situation from 1 to 2 craft results in an 80% increase in PSR (.200 v. .360) which should lead to significant increases in PMOs in most situations and MOs for most scenarios.

These more involved modeling situations that include multi-FC permutations were not addressed due to budgeting and reliability considerations. If this FC occupation aspect was to be included every possible number combination of FC in each potential safety risk portion of each SOC would need to be considered as would every possible location and float speed of each FC.

The modeling approach used should result in some underestimation of PMOs and MOs. While the magnitude of inaccuracy is not known the relative magnitude of impact can be anticipated by the Upper Galice Safety Risk/Conflict Curves in Chapter VI. The relatively low predicted PMOs at high FC use levels indicates that this assumption may have dramatic effects on predicted MOs, particularly in long SOCs with high PNSs. On-river observations indicate that FC tend to float in clumps with considerable craft overlap in SOCs. This would indicate that when FC are encountered in SOCs by MTBs chances are good that more than 1 FC would be present in specific hazardous portion of the SOCs.

d) Craft speed information was generated from a limited data set;

Both FC and MTB speeds in SOCs were calculated using field observations and video tape measurements of transit times between known locations. Even though the field data at the SOCs was collected on approximately 84 sample days, the FC and MTB speeds used in the SOC Assessment could be improved through a more thorough data collection process. Any speeds developed from additional data would provide a more reliable estimates of PROs and the PSR results of the SOC Assessments which could result in changes in PMOs and the MO estimates from the SR/C model.

Also, speeds used in the SOC Assessments to derive the PSRs were calculated from data collected at all flow levels. The collection of more craft speed data for FC and MTB at different flow levels could allow the use of variable craft speeds for high and low flow conditions as part of the SOC Assessment PSR variables. This would allow for more accurate PSR, PMO, and MO estimates for the two flow conditions.

e) Drifting speeds for MTBs are assumed to be 1.5 times the average FC speed in the area the MTB is drifting;

This assumption was made to help calculate MTB operation times in SOCs when drifting options were available. The average FC speed for the MTB drifting portion of the SOC was used as an estimate of average current speed. The 1.5 factor was used to accommodate the need for positive navigational control in areas with confined currents and turbulent hydraulics such as runs and tailwater areas.

If MTBs can be safety navigated in SOCs at less than 1.5 the current speed then the SOC Assessment PSRs and PMOs will be lower and there would be fewer MOs than those predicted by the SR/C Model. If the average FC speed does not accurately reflect the current speed through the MTB drifting area the SOC Assessment PSRs and PMOs will be inaccurate. Should the current speeds be more accurately estimated from the slow FC speeds (a distinct possibility), the MTB float speeds used in the SOC Assessments will be too high. Slower MTB drifting speeds would reduce the likelihood of overtaking FC and SOC Assessments would result in lower PSRs and PMOs. This would result in fewer MOs than those predicted by the SR/C Model but only for downstream MTB operational directions.

f) Safe craft separation threshold distances were designed to accommodate multi-FC situations in which MTBs could not pass FC in the process of stopping;

Safe MTB stopping distances were based on straight-line PSDs so that MTBs can maintain adequate craft separation distances during stopping maneuvers. Minimum straight-line stopping distances were assumed to be the minimum safe stopping distances because of the aggravated safety hazards when a MTB encounters multiple FC. In this situation the MTB operator has fewer maneuvering options and the option for a passing stop may not be available. Therefore every MO situation is based on assumptions that there are multi-FC present and they are floating side-by-side such that a passing stop maneuver is not possible without also exceeding safety craft separation distance thresholds.

Most MO situations are in relatively narrow channel areas and passing stops would also exceed safe craft separation distance thresholds where only a single FC is involved. This would result in MOs. There are some areas however, that are wide enough that a MTB could undertake a passing stop maneuver past a single FC and not exceed safe craft separation thresholds. In these situations the PSRs and the resulting PMOs and MOs in the model overestimate safety risks. Conversely it is in these wider areas that FC are more likely to be floating side-by-side which reduces the available space for a MTB passing stop maneuver. Therefore this assumption probably overestimates PSRs in some SOC/scenarios but the resulting MO differences are most likely to be exceedingly small.

g) The SOC Assessment parameters were not field tested;

Time and funding limitations and the lack of the MTB owner/operator cooperation with the BS/C Study prevented the field testing of safety risk parameters developed by the FG and WRC. With respect to the SOC Assessment and SR/C Model results the parameters of greatest importance include; MTB PSDs, MTB SSDs

which include assumptions of appropriate safe craft separation distance, MTB drifting speeds, and the assumptions of adequate safe craft separation for various MTB operational modes.

Although field testing these parameters were not possible the SR/C Model conclusions as to safety risk potential generally conform to the perceptions of members of the FG. This indicates that while there may be inaccuracies in MO predictions for specific situations or operational approaches, the SR/C Model outputs provide good measures of relative safety risks between sets of conditions. The areas in which the SOC Assessments results were at odds with the FG member perceptions included: 1) the relative safety of upstream and downstream MTB operations; 2) the relative inherent safety risks of SOCs in the Scenic Section and the Whitewater Section; and 3) the relative safety risks between the low and high flow conditions in the Whitewater Section.

While JB and FC users felt that upstream operations were safer because it is easier to stop MTBs when running into the current, the SOC Assessments found downstream operations safer because the MTB operator's knowledge fields at SOCs increase during downstream operations. It appears that the safety risk significance of LOS thresholds during upstream operations was not appreciated by the frequent user members of the FG. With regard to this factor it appears that the model results more accurately reflect actual safety risk potential than does the user perceptions.

JB and FC user members of the FG and the WRC field team felt that the Scenic Section was an area of less safety risk when compared to the Whitewater Section, however, the SOC Assessment results showed that the average SOC safety risk parameters were more risky in the Scenic Section (higher average IRS). This indicates an apparently contradiction between user and field perceptions and the SOC Assessment results. When the MTB use schedule and the daily FC use pattern parameters were introduced and the SR/C Model was executed, the model results showed that: 1) on a trip by trip basis Whitewater MTB trips had much higher average safety risk potentials than did the Scenic MTB trips; and, 2) the Whitewater Section and the Scenic Section had roughly equal seasonal potential safety risk exposure even though the Whitewater Section only had 2 MTB trips daily and the Scenic Section had 5 or 6 MTB trips daily. Therefore we assume that the FG user and field team perceptions of greater potential safety risk in the Whitewater Sections were a product of interjecting the use level and pattern factors onto the purely physically based safety risk aspects of the SOCs. As a result we find that there may not be a contradiction between user perceptions and the model results.

JB and FC users members of the FG felt that the safety risk potential of the Whitewater Section increased greatly under low flow conditions while in the Scenic Section safety risks were relatively insensitive to flow conditions. Conversely, the SOC Assessment results indicate that the Scenic Section SOCs are more sensitive to flow conditions than are the Whitewater Section SOCs. A review of the individual SOCs showed that the flow sensitivity of the Scenic Section SOCs was due to loss of downstream drifting options and slightly more restrictive set-down threshold locations. The insensitivity of the Whitewater SOCs was due to the narrower and more pronounced channel bottom topography that resulted in essentially no change in MTB operational options with flow conditions. Even though the effective channel area is greater under higher flow condition the SOC Assessments indicated that the additional widths were not great enough to provide non-MO co-occupation of the SOCs. In this instance it is possible that the safe craft separation distances developed through the FG process were set at a magnitude that show no change in safety conditions between the effective sizes of the channel under the two flow conditions. This could result if safe craft separation distance were either too large or too small to reflect changes in effective channel width, or, that the perceived change in safety risk potential with flows result from a perceived change in channel conditions and not the actual changes that occur. It is also possible that FG member input included perceptions of possible accident outcome severity rather than simple craft separation parameters. If this factor was included the generally tighter and the more hydraulically intense rapids of the Whitewater Section could have added to the apparent skew between the user perceptions and SOC Assessment and SR/C Model results. In the case of the assumed safe craft separation distance parameter, field testing would have been beneficial for improved SOC Assessment and SR/C Model reliability.

Although many of the apparent contradictions between field and user perceptions and the results of the SOC Assessments and the SR/C Model can be variously explained, field testing of acceptable safe craft separation distances

using a broader user base than the FG members could result in different perceptions of adequate craft separation. In addition it may be discovered that user perceptions of adequate craft separation will not only vary with MTB operation modes but also with local channel/hydraulic conditions. In this regard perceived adequate craft separation threshold distances could vary either directly or inversely with perceived effective channel area and the perceived avoidance options available to MTBs. This field testing could shed additional light on why the FG members thought the Whitewater Section SOCs were more hazardous than Scenic Section SOCs, and why there was a perception that the Whitewater Section safety risks were strongly influenced by flow condition. The SOC Assessments and the SR/C Model results only weakly agreed with these strongly held perceptions. Field testing could be used to introduce new or more complex safe craft separation thresholds which could result in different SOC/scenario safety risk parameters and different MRS MO estimates for any given recreation management scenario.

h) MTB operational rules at SOC RIPs allow MTB operators to proceed once the knowledge field or the view field from the RIP is clear;

When operating downstream MTB operator rules call for the MTB to stop at the RIP should a FC be observed in the SOC. The MTB operator is assumed to wait at the RIP long enough for the observed FC to float to the ST before the MTB run is re-initiated. For those MTBs that stop at RIPs and re-initiate runs after waiting, this rule eliminates safety risks associated with overtaking through-running and time-dependent pop-out FC and the residual PSRs would only concern the probability of time-independent pop-out risks. This rule assumes that the MTB operator has a perfect knowledge fields for all SOCs in all conditions for all FC that may be encountered. This would include consistently perfect knowledge of the FC float times and patterns which would assure that any observed FC has reached the ST, and consistently perfect estimates of the appropriate MTB wait time for every situation.

Observations made during the 1992 field season indicate that MTB operators seriously overestimate the speed of FC and underestimate the length of time required for a FC to float to the bottom of the SOCs. This is the case even when FC are simply floating through the SOC following fastest currents. Unusual situations such as broaching or wrapping on rocks or swimmers from rafts getting stuck in channel sections will result in substantially longer SOC transit times. While necessary for appropriate modeling, the assumption that MTB operators always accurately estimate the wait durations that accommodate typical FC uses, it is not a reliable expectation. As a result, for downstream operations, real MOs are more likely than the estimates that result from the SR/C Model.

For upstream MTB operations, knowledge fields do not extend beyond the view fields regardless of wait duration, therefore a premature run re-initiation would occur when FC are observed in the SOC which would be an Overt MO, not an underestimation of MOs.

As a result of these assumed operational rules and observations of actual MTB operations the downstream PMOs in the SOC Assessments are somewhat underestimated. The magnitude of underestimated PMOs would be particularly large for the longer SOCs with longer unseen areas and very small for the short SOCs with very short unseen areas. Upstream MO model estimates are not skewed by this assumption.

i) MTB trip schedules are not modified for accumulating wait duration;

When the SR/C Model predicts wait incidents and average wait duration for a specific lead MTB running a specific SOC on a specific MTB trip itinerary schedule, the average wait duration is not used to modify the MTB trip schedule. The accumulation of wait duration as the lead MTB progresses through the trip itinerary schedule would in fact force MTBs to run late which could change the 15-minute interval at which the lead MTBs arrive at subsequent SOCs. This could result in encountering either greater or lesser numbers of FC and could change the safety risk and conflict implications of specific MTB trips.

While this is technically a potential issue, two factors make it reasonable to leave the schedule unmodified by wait incidents. First, wait incidents and durations are measures of accommodation incurred by all use activity types to avoid MOs at SOCs, therefore waits and wait duration is not borne exclusively by the MTBs. Second, should wait duration be accumulated during a specific MTB trip, MTB operators are expected to modify trip activities such that a reasonable schedule is

maintained. These modifications may include, reduced off-plane interpretive time, the elimination of spins, and faster on-plane speeds in non-SOC areas.

j) Time-independent pop-outs are assumed to occur consistently throughout the recreation day;

Time-independent pop-outs are those situations in which FC can be unexpectedly encountered in SOCs due to FC user behavior patterns unrelated to the time that has expired since the FC entered the SOC. Because of these behavior patterns, regardless of the duration of an MTB wait at the SOC's RIP, the MTB operator can not anticipate the presence of FC. These activities are typically: 1) stops for lunch in an SOC in which the time that the FC launches after lunch can not be estimated; 2) FC playing for extended periods of time in rapid hydraulics, tailwater areas, or eddies; 3) FC users stopping to swim riffles; and, 4) FC being carried part way up the SOCs by users to re-float the rapid.

The FC use patterns used in the SOC Assessments to address the issues of time-independent pop-outs were collected throughout the recreation day and were expressed as a percentage of total activity. When used in this manner it was assumed that these user directed behavior patterns are a function of FC use levels and not recreational choices that may vary through the recreation day. Therefore, as an example, in the model pop-outs associated with a lunch stop at a particular SOC would vary with the number of FC at the SOC through the recreation day, not necessarily the time of day in which lunches are typically taken. In nearly all time-independent pop-out situations, the behavior pattern observed were related to prolonged lunch stops or afternoon stops when the trip ending take-out was in close proximity. Because these time-independent pop-out behavior pattern incidents were averaged over the entire recreation day, their occurrence will tend to be overpredicted in the morning and late afternoon hours and underpredicted between about 1100 and 1600 hours. This results in modeled MO estimates that may be slightly too high for MTB SOC runs that occur before 1100 and after 1600 hours and too low for MTB SOC runs that occur between 1100 and 1600 hours.

Although this modeling factor is recognized as one that could lead to inaccurate BS/C results at specific SOCs and for specific MTB trip itinerary schedules, the degree of precision gained by adding this factor was seen as being compromised by other SOC Assessment and SR/C Modeling assumptions; particularly the lack of specific study reach MTB PSDs. Should it prove useful in the future the model could be upgraded to incorporate varying time-independent pop-out probabilities for different specific 15-minute intervals for specific SOCs.

k) SOC Assessments are based on 1992 channel conditions;

The SOC Assessments were conducted using the channel characteristics observed in the 1992 field season. The identified set-down areas, set-down thresholds, MTB driftable reaches, and operational shoals played important roles in setting MTB operational limitations. The MTB operational limitations were controlling factors in the identification of SOC conditions, setting the limits of SOCs, and identifying MTB operational modes with the SOCs. All of these factors are primary parameters driving the BS/C conclusions of the modeling effort.

Field review of the channel conditions in the Hellgate Study Reach indicate that it is actively transporting coarse grained sediment and that bedforms and channel alignment patterns are likely to change with time. While channel dynamism is particularly active in the Scenic Section, the overall channel morphologic regime is likely to remain the same with the same pattern of fluvial geomorphic features, at specific sites the locations and spatial relationships of the features are likely to shift. With changing site specific conditions the locations and characteristics of SOCs will change as will the SOC PMOs. As a result the SOC Assessments and the SR/C Model safety risk conclusions are applicable to the channel conditions of 1992. Should channel features change new SOC Assessments will need to be conducted and new SR/C Model runs undertaken to estimate safety risks and conflicts. In the Gold Hill Study Reach channel conditions are relatively stable and while change is likely, the rate of changing SOC conditions should be very slow compared to the SOCs of the Hellgate Study Reach.

VI. BOATING SAFETY AND CONFLICT PROBLEMS

A: Introduction

This chapter presents the general BS/C issues identified in the Rogue River Study Area. These issues were developed through on-river observations by the WRC field team, the results of the SOC Assessments and the SR/C Model, input from on-river users contacted through the field season, input from the cosponsoring agency staff and, on the Hellgate Study Reach, input from members of the Focus Group.

The following are discussions of the major BS/C issues discovered and some suggestions for recreation management modifications that could reduce BS/C issues and concerns on both study reaches. The potential influence of these possible management modifications on BS/C issues are addressed. In some cases the estimated implications to safety risks and conflicts are quantitative and are based on the MO outputs of SR/C Model runs, in other cases the estimated the BS/C implications are qualitative and are based not on SR/C modeling, but on on-river observations by the WRC field team and input from users, agency staff, and FG members.

B: Hellgate Study Reach

The BS/C Study scope was primarily directed at the BS/C concerns on the Hellgate Study Reach and most of the 1992 field work was conducted in that area. As a result of more than 140 field and sample days on the Hellgate Study Reach, sufficient use and user data were collected to allow the full development of the principal components of the SR/C Model. These components include: 1) a FC Use Distribution Model that can reasonably reflect the daily FC user pattern at different SOCs at different times of the day on different day-types; and 2) SOC Assessments that reasonable reflect the FC user pattern in SOCs and FC speed distribution through important areas of SOCs which allow for the development of quantitative safety risk parameters (PROs, PNSs, PMOs, etc.). The development of these model components on the Hellgate Study Reach allowed for the use of the SR/C Model in evaluating many of the identified BS/C issues quantitatively as well as to develop quantitative estimates of the BS/S implications of recreation management modifications. The SR/C Model estimates of safety risks were based on 1992 channel conditions and on 1992 FC and MTB use levels and patterns.

Some of the Hellgate Study Reach BS/C issues discussed below were presented in more detail in the separately bound Appendix L: "Draft Safety Recommendation Elements - Safety Risk and Conflict Implications". Those BS/C issues that are treated more thoroughly in that appendix volume are marked with a *; refer to that appendix for additional information.

1) Streamflow Magnitudes and Safety Risks:

It was initially recognized by the cosponsoring agencies that BS/C issues vary with streamflow and that at lower flows safety risk and conflict problems are intensified due to reduced navigational clearances and reduced margins of safety. The variable risk induced by streamflow magnitude was corroborated by both JB and FC operator members of the FG. The BS/C Study field work also noted changes in hydraulic conditions and general operating room that resulted in both greater risks and reduced margins for safety at lower flows. SOC Assessment and SR/C modeling were based on two channel hydraulic conditions: 1) an unspecified low flow condition with greater levels of safety risks; and, 2) an unspecified high flow condition with lower levels of safety risks.

The physical characteristics of the SOCs that represented MTB operational limitations for these two flow-related channel hydraulic conditions were developed through on-river measurements and photo atlas review by the MTB operator and pvt-JB operator members of the FG. The daily staff gage reading of the U.S. Geological Survey (USGS) gage at Grants Pass indicated that at the time of field work and initial evaluations, the flows that typified the low and high flow channel hydraulic conditions of the SOCs were about 850 cfs and about 2250 cfs respectively. However, for the SOC Assessment approach and SR/C Model application these two safety risk-related flow conditions were functionally defined as the physical channel hydraulic conditions that are typical of: 1) higher flows that characteristically occur during the MRS when MTB options are optimal and safety risks are

minimal; and 2) lower flows that occasionally occur in the MRS in which MTBs are still operating but safety risks are higher due to more restricted MTB options. The low flow conditions would not apply when flows are too low for MTB navigation.

These two flow ranges were unspecified during the assessment and modeling steps because it mattered only that there were two flow-dependent channel hydraulic conditions that impart varying degrees of safety risks. The actual flow boundaries in cfs for these flow ranges are not important until the SOC Assessment and SR/C Model findings are applied to a specific study area, study reach, and/or study reach section, until safety risks associated with an actual streamflow regime are evaluated, or until management actions are contemplated. While much of the BS/C Study involves determining the relative safety risks associated with the both high flow and low flow conditions, the question addressed here is determining the threshold flow that separates the streamflow continuum into the discrete safety risk-related flow ranges on the Hellgate Study Reach.

During the BS/C 1992 field season streamflows were popularly reported (daily staff gage reading from the USGS Grants Pass gage by City of Grants Pass personnel) to have been predominantly in two discrete ranges; between about 790 and 1000 cfs prior to August 12 and after September 22 and between 2000 and 2300 cfs from August 14 to September 11. Only from September 12 to 22, did streamflows range between these two flow categories. As a result there was sufficient time to review site conditions at both lower flows and higher flows, but there was little opportunity to review intermediate flows. This limited the possibility of determining a threshold flow that could, from the perspective of relative safety risk exposure, be use appropriately to separate higher flows from lower flows.

The BS/C Study scope, developed by the cosponsoring agencies, implied that lower flow conditions exist from 900 to 1200 cfs and higher flow conditions exist from 1300 to 2300 cfs. Most river-knowledgeable members of the FG noted during various meeting secessions that lower flows imparted higher MTB/FC encounter safety risks. The MTB operator, pvt-JB operator, and two commercial FC operator members of the FG all noted that the varying streamflow magnitudes which have been experienced during the MRSs of recent years result in notable safety risk differences. They also stated that the differences are great enough that the SR/C Model would have to differentiate the risks and that management approaches would need to be different for these flow conditions (Appendix K; Focus Group Meeting Notes, 69, 78, 93, 106-7, 116). In reference to low and high flow conditions, the MTB operator member indicated that in general throughout the study reach, the set-down area options are the same but that at lower flows some drifting options are lost and higher speeds would be necessary in some riffles (ibid., 45, 146). He also noted that low flow conditions have a more significant bearing on safety in the Whitewater Section than in the Scenic Section resulting from the exposure of more scattered rocks in a narrower channel as opposed to the generally wide channel conditions of the Scenic Section (ibid., 93).

The FG members offered input as to the flows that would be appropriate to bound the outer margins of the low and high flow conditions but were generally vague as to the specific flow that separate the higher, less risky flows from the lower, more risky flows. The MTB operator member noted when streamflows get particularly low, MTB trips in the Whitewater Section stop at the top of Carpenter's Island and at the top of Ennis Riffle for navigational/MTB craft safety concerns (ibid., 45, 143). The MTB operator member indicated that the MTB operations stopped at the top of Ennis Riffle at 900 cfs and ran to that location at flows at least down to 790 cfs, the lowest reported flow of the 1992 MRS (ibid., 45, 118). The MTB and pvt-JB operator members of the FG stated that at flows above 2200 cfs, channel hydraulic conditions induced no JB operational limitations (ibid., 78) which may indicate an upper streamflow boundary on high flow channel conditions. The MTB operator and a commercial FC owner/operator member of the FG indicated that there was a significant safety risk change in the 1000-1500 cfs range (ibid. 93) which was their inference as to the threshold flow that separates low and high flow channel conditions.

Published streamflow gage data for the 1992 MRS was released by the USGS in 1993. To estimate the actual streamflows that may have been present in the Hellgate Study Reach below the gages during the 1992 MRS, the reported streamflow information from the Grants Pass gage on the Rogue River and the Wilderville gage on the Applegate River were combined with the gaged Rogue River streamflows at Agness about 72 miles below Grants Pass (to account from tributary accretion). When these computed flows were compared against those reported by the City of Grants Pass, Water Filtration Plant staff during the MRS, several streamflow measurement problems emerged. First, the lowest daily average flow at the Grants Pass gage (7/17/92) was really 976 cfs instead of the 790 cfs reported during the MRS. Comparisons between the "actual" streamflow magnitudes at Grants Pass as published after the end of the MRS and the daily staff gage flows reported during the MRS, indicate that the streamflows that users think are occurring during the MRS can be significantly less than actual flows. This is confirmed by USGS personnel that reported that a discrepancy between the daily staff gage readings and corrected flows as large as 200 cfs

can develop through the summer season due to progressive changes in the channel bed hydraulic controls at the gage (House pers. comm.).

Second, Applegate River flow contribution to the Rogue River can vary between 50 cfs and several hundred cfs during the MRS. On the day that flows at Grants Pass were the lowest during the 1992 field season, the Applegate River was contributing about 53 cfs. The flow on the Rogue River below the Applegate River confluence (RM 6.6) on the lowest day of the 1992 MRS was about 1029 cfs according to upstream gages on the Rogue and Applegate rivers instead of the reported 790 cfs.

Third, when watershed accretion flows are considered, ungaged tributaries downstream of gages can make significant contributions to streamflow. Using monthly average flows as recorded on the Applegate River and the Rogue River above the study reach and on the Rogue River below the study reach at Agness, monthly average watershed accretion was calculated on the basis of cfs per square mile. For three example MRSs that may be representative of typical low, average, and high water years (1992, 1993, and 1984) (House pers. comm.) average watershed accretion estimates in the study reach ranged from zero to 1.06 cfs per square mile. Along the 33.3 mile long Hellgate Study Reach, streamflows as measured at the upstream gages are augmented by contributions from about 461 square miles of tributary watersheds (excluding the 168 square mile Grave Creek watershed that contributes flow immediately above the downstream end of the study reach). Therefore, relative to the upstream gaged streamflows, increased streamflows along the study reach could range from nil to as much as 490 cfs or more during the MRS. Inspection of general watershed conditions indicated that when watershed accretion is very low in the MRS, actual streamflow augmentation below the Grants Pass and Wilderville gages and above Finley Bend (RM 9.5), can be significantly greater on a cfs/square mile basis, than the computed average because of irrigation returns flows.

To represent possible flows in the Whitewater Section a single location was selected as the focal point for computations. The mouth of Zigzag Creek (RM 19.6) was selected because it is the location that separates the Scenic and Whitewater sections of the study reach, and, because it is located at the upstream end of the Whitewater Section and is a conservative location for estimated flows in the Whitewater Section. At Zigzag Creek, gaged flows may be augmented by contributions from 371 square miles of ungaged watersheds.

When the three factors that lead to underestimated streamflows were considered (inaccurate streamflow gaging at Grants Pass, Applegate River contributions, and watershed accretion) the lowest flow in the Whitewater Section in the 1992 MRS, as computed at Zigzag Creek, could have been about 1050 cfs instead of the reported 790 cfs. When the foregoing streamflow measuring attributes were considered together it appears that actual flows in the study reach (at Zigzag Creek) could be 250-400 cfs greater than the "real-time" flows at Grants Pass as reported during the MRS.

When actual MTB operations observed in the 1992 MRS were compared to computed streamflow as adjusted for Zigzag Creek, the threshold flows noted by the FG as being significant to safety risk considerations and MTB operations were different than those popularly held. Based on the above modified streamflow computations the MTBs were observed to run the entire Whitewater Section through Upper Galice Chute to Grave Creek until flows dropped below about 1400 cfs. At that flow MTBs stopped at the top of Carpenter's Island (RM 24.6). At about 1300 cfs MTBs stopped running Ennis Riffle, stopping at the Ennis Boat Ramp (RM 23.8) to turn around. These flows indicate that the minimum MTB navigation flow for the entire Whitewater Section was about 1500 cfs (as calculated at Zigzag Creek).

On June 22, 1992, when the computed daily average flow at Zigzag Creek was about 1270 cfs, the MTB owner/operator informed the BLM that flows in the Scenic Section were too low to ensure adequate navigational margins and requested permission to place sand bags in several SOCs to enhance water depth through the channel areas used by the MTBs (Schoblom, pers. comm.) (See Figure 23). This request was made 4 days after the computed flows dropped below 1500 cfs and 1 day after the computed flows dropped below 1300 cfs. From this request it appears that minimum MTB navigational flow on the Scenic Section during the 1992 MRS was about 1300 cfs.

From the above streamflow information, the perceptions and attitudes expressed by FG members, and observations of the actual MTB operational adjustments undertaken to accommodate the flow regime of the 1992 MRS, WRC-Environmental specified specific ranges for the high and low flow channel conditions on the two study reach sections. Low flow conditions, those flows between the limits of MTB navigation and the threshold to higher flows with less risky channel conditions were assumed to occur between 1300 cfs and 1800 cfs on the Scenic Section and between 1500 cfs and 1800 cfs on the Whitewater Section (as computed at Zigzag Creek). High flow conditions, those flows between a lower more risky flow condition and some higher, notably less risky flow was assumed to occur between 1800

cfs and 2500 cfs in both study reach sections. The flow used to separate higher safer flows from those lower flows with reduced margins of safety was based on the premise that with declining streamflows, adequate safety margins, relative to encounters with other users, will degrade before MTB navigation limits are reached and that a threshold flow that separates higher from lower flows from the perspective of safety risks would be somewhat greater than navigational limits. For safety risk and conflict assessment purposes 1800 cfs (as computed at Zigzag Creek) was adopted as the threshold flow that separated low and high flow conditions on both sections of the Hellgate Study Reach.

At most SOCs the transition from low flow to high flow channel/hydraulic conditions does not occur at a single discrete flow level but rather occurs gradually over a broad flow range, perhaps several hundred cfs or more. It is also true that not all SOCs shift in flow-related safety risks at the same flows. As an example the channel/hydraulic conditions at Hellgate Riffle change dramatically at a computed flow of about 1200-1400 cfs and the inherent safety risks at this SOC double over this transition flow range (See following section and Table 3). This flow is about the same as the assumed MTB navigational limits on the Scenic Section but at this SOC, hydraulic conditions are such that they may be considered as being in the high flow, less risky range. Conversely at other SOCs, particularly upstream SOC/scenarios in the Whitewater Section, channel/ hydraulic conditions changed with flows but not enough to result in altered inherent safety risks over the flow range evaluated. The 1800 cfs threshold is therefore understood to be an arbitrary value that represents a flow range over which general channel hydraulic conditions shift in the Hellgate Study Reach between relative degrees of safety risks.

While one FG member thought that a threshold flow of 1800 cfs was a valid conservative value to use in separating flow-related channel hydraulic conditions and to use as a framework for initial management, most FG members who expressed opinions thought that the threshold flow should be lower; suggestions ranged from 1450 cfs to 1600 cfs as calculated at Zigzag Creek (Appendix K, 148). Most of the discrepancy between WRC's (1800 cfs) and the FG's (1400-1600 cfs) threshold flows is probably attributable to a long standing misconception of day-to-day flows (250-400 cfs difference) during the MRS associated with the streamflow measuring problems explained above. This may have established an erroneous perception of streamflow/channel hydraulic condition relationships in the minds of the users.

The MTB operator member stated that they limit their operations at the top of Carpenter's Island at 1400 cfs (as computed at Zigzag Creek) to accommodate safety risk with FC users not just for MTB navigational concerns and therefore they were already accommodating BS/C issues with the modified operations (ibid., 147-8). The BS/C field work and the assessment undertaken in the BS/C Study indicate that MTB operators do not fully understand nor appreciate the degree of safety risks associated with MTB operations in the study reach, particularly with regard to the locations of LOS thresholds and their potential implications to safety risks. Therefore it was our conclusion that the 100 cfs difference between MTBs stopping at Ennis (RM 23.8) and Carpenter's Island (RM 24.6) was actually a MTB navigational issue in Upper Galice Chute.

Additional field work over a more complete flow range than was available during the 1992 field season could serve to more accurately establish an appropriate threshold flow.

2) SOC Hazards:

The SOCs were initially identified as reaches of channel in which MTB operators can not see the entire MTB route from one safe stopping location to the next. These SOCs were identified as locations in which channel characteristics could limit the ability of craft operators to avoid safety risk exposure situations. There are two basic elements in the evaluation of safety risks and hazards at the identified SOCs: 1) the probability that, even when using the best operational practices, JBs can not be operated to avoid potentially hazardous situations (MOs); and, 2) the relative severity of any accident should one occur in these situations.

For each SOC/scenario the probability for MOs were estimated in the SOC Assessment and are displayed in Plates 2-66. The potential severity of each MO circumstance in each SOC/scenario is addressed in detail separately in the Hazard Severity Rating (Appendix H). Issues that related to inadvertent safety risks in the SOCs for both MTBs and pvt-JBs are presented in sections a) and b) below. These issues include the findings of the SOC Assessments and the SR/C Model as well as the on-river observations by WRC field staff during the 1992 field season.

a) MTB - SOC Probability of Risk; As presented elsewhere the relative levels of BS/C for each SOC/scenario were calculated based on the probabilities that, under

the best of conditions, potential accident or safety risk situations will occur; Mutual Occupation (MO) incidents. A MO was defined as unavoidable, inadvertent MTB/FC encounters in SOCs at less than acceptable craft separation distances. A MO is a MTB/FC encounter in which the outcome, with respect to an actual accident occurrence, is dependent on the particular actions of the operators of the craft in each particular situation within the context and confines of the physical configuration of the channel and the operating characteristics of the craft involved. Contributing factors of the actual outcome of individual MOs include, among others, the reaction time and cognitive ability of the MTB operator to recognize and interpret the situation correctly, the confines of the physical configuration of the channel at the location of the MO, the number of FC involved, the precise location, spatial distribution, and timing of activities of all the craft involved, the skill of the MTB operator in controlling the MTB during evasive maneuvers, the stopping and maneuvering characteristics of the MTB craft, the reaction and skill level of the FC operators, and the actual decisions made by all craft operators. Therefore the calculated MOs do not estimate when and where MTB/FC accidents will occur but rather the probabilities that encounters with accident potential will occur. A MO is an incident that involves safety risk exposure.

Among other factors used as the basis for calculating these MOs was the assumptions that MTB operators at all times use the highest skill levels, make the most prudent and best informed decisions, that they will at all times operate MTBs so as to avoid BS/C issues with other users, and that operator decisions are limited by the visual information available under each situation. These assumptions were incorporated during the SOC Assessment process in which LOS limitations were used to calculate the probabilities that FC are visible from the RIP. With the above "best" MTB operational practice assumptions a MO was further defined as an unavoidable safety risk exposure incident.

The basic best and most prudent MTB operation assumptions used in the SOC Assessments result in MOs representing a minimum estimate of unavoidable safety risk exposure. Anything less than expert MTB operating skills and absolutely prudent operational decisions could result in greater frequencies of safety risk exposure. This could occur in SOCs as well as the creation of safety risk exposure in non-SOC areas. In this BS/C Study, safety risk situations induced by less than best MTB operational practices are referred to as Overt MOs. Overt MOs in SOCs could result from such MTB operational practices as: 1) entering SOCs when FC are observed; 2) operating at speeds too fast to stop safely to abort a SOC run at a RIP; and, 3) human error, etc. Overt MOs in non-SOC areas can result from MTBs passing FC on-plane at close distances when off-plane operations and/or greater separation distances options were available. Several incidents of Overt MOs in non-SOC areas were observed during the 1992 season, some of which escalated into shouting matches between craft operators. Safety risks and potential accident situations in non-SOC areas can be avoided by setting-down the MTB to drift past on-river and bed and bank users, and by passing users on-plane at acceptable distances. Overt MOs occur in both SOC and non-SOC areas when MTB operators violate the basic rules of prudent MTB operations assumed in the BS/C Study.

For BS/C risk probability modeling purposes, MOs were defined on the basis of inadvertent circumstances in which MTB operators were unable to avoid MTB/FC encounters where craft separation distances were less than identified safety thresholds. The causes of inadvertent circumstance include line of sight, channel depth, and MTB operational limitation characteristics, etc,. By definition, in non-SOC areas there is enough channel visibility, effective channel width, and MTB operational options available that MTB operators can accommodate MTB/FC encounters without violating parameters of acceptable craft separation. Overt MOs were not safety risk situations inherent to the channel characteristics and the boating use characteristics of the study reach and, by definition, were not part of the BS/C safety risk assessment.

Another assumption used in the SOC Assessments which would result in minimum BS/C estimates was that all MTB trips are led by a "Medium" sized MTB. The MTBs in use on the Hellgate Study Reach were not tested for physical stopping distances (PSDs) because the MTB operator/owner on the Hellgate Study Reach refused to cooperate in this part of the BS/C Study. The SOC Assessments are based on the assumed PSD for "Medium" sized MTBs based on stop tests conducted on the Lower Rogue River. The "Large" sized MTBs often used as lead craft in the Hellgate Study Reach are likely to have longer PSDs and therefore, safe stopping distance (SSDs) would also be longer (See Figure 8 and Table 1). Many MTB trips on Scenic Section itineraries were led by these "Large" sized craft and any PSR calculated in the SOC Assessments for a MTB run through any SOC/scenario would likely underestimate the

actual probability for a potential accident situation. Although there are "Small" sized MTBs listed as in use on the Hellgate Study Reach, during the 1992 field season none of these craft were observed on any of the MTB trips and therefore were never observed to be the lead craft on a MTB trip.

When best operation assumptions, Overt MO safety risks, and the use of "Large" MTBs as lead craft are considered, the calculated MOs in the SR/C Model represent a measure of minimum potential safety risk exposure for any given recreational management scenario. Actual incidents of safety risk exposure will be greater because less than "best" and "most prudent" MTB operational practices in SOCs and non-SOC areas have occurred and are likely to occur in any given MRS. These additional incidents of safety risk exposure will occur in many portions of the study reach and, along with the reduced margins of safety induced by the use of "Large" sized MTBs, leads to the conclusion that the modeled MOs are minimum estimates of actual safety risk exposure.

The SOC Assessments resulted in the fundamental conclusion that under both low and high flow conditions, and in both MTB operational directions there are situations in nearly all SOC/scenarios that result in inadvertent safety risks even with the best of operating skill and judgement. That is, for the 1992 channel conditions, for the FC and MTB operational patterns observed, and for the assumed MTB operational characteristics, it is not possible for MTBs to be operated in such a way as to avoid incidents that include the potential for accidents. Under the MTB operating assumptions used in the SOC Assessments, the channel configurations and FC user patterns that were present during the 1992 season, and within the resolution specificity of the SOC Assessment fault-tree risk approach, unavoidable accidents are possible in nearly all the identified SOCs. Only two SOCs had PSRs of zero for each of the four scenarios. These were Applegate and Two-bit Riffle. The resulting PSRs for each SOC/scenario are presented in Table 3.

SOC Assessments revealed several safety risk aspects of the SOCs that result in useful observations; these include the relationships of PNSs, PSRs, and Inherent Safety Risk (ISR) with various physical parameters of SOCs, streamflow magnitude, and MTB operational direction. The ISR for each SOC/scenario assumes that one FC is in the SOC when the MTB arrives at the RIP. It is the product of the PNS and the PSR and represents the likelihood that, when a FC is in the SOC when a MTB arrives, it is both unseen from the RIP and will be involved in a MO if the MTB initiates the run. The ISR is the mathematical equivalent of the Single-FC PMO in the SOC Assessment chapter.

The ISR is the "inherent" safety risk of the SOC/scenario because it is based on three attributes: 1) the physical characteristics of the channel in the SOC; 2) the particular JB use patterns at the SOC and the craft characteristics of the JBs in use in the study reach; and 3) the particular FC use patterns at the SOC and the craft characteristics of the FC in use in the study reach. It does not include the number of potentially conflicting craft at a specific SOC at a specific time which would relate safety risks to use levels. The ISR can be used to compare SOCs and SOC/scenarios on the basis of relative degree of physically-based safety risk as well as to compare the SOCs of other rivers should similar BS/C studies be conducted on other river resources.

The primary safety risk aspect of SOCs is dictated by the general physical configuration of the SOCs including the visual field into the SOC from the RIP as a percentage of the whole SOC, the maneuvering options available to MTB operators once in the SOC, and the FC user patterns in the SOCs. Those SOCs with nearly full visual access throughout have very low PSRs because almost all FC that would be at potential safety risk are observable from the RIP and can be accommodated by MTB operator decisions prior to entering the SOC. Those SOC/scenarios with larger PNSs generally also have longer distances for FC to float to reach the ST. Therefore the magnitude of PNSs and PSRs are often related and, when multiplied together to develop ISRs, the effects are compounded. SOC Assessment results (Table 3) can be used to observe some the influence of PNS on ISRs. The proportion of the FC float route that is not observable (PNS) from the RIP for Argo and Wooldridge are fairly small, .117 and .038 respectively, for downstream operations at low flows. The PSRs for these SOCs are also relatively small, .198 and .043 respectively, which result in ISRs of .023 and .002. Brushy Chutes and Middleton's for downstream, low flow scenarios have greater shadow zones with PNSs of .586 and .429, and greater PSRs of .456 and .507 resulting in ISRs of .267 and .218 respectively. The physical conditions of these last two SOC/scenarios, when compared to the first two, result

in the FC in the SOCs being 4 to 10 times less likely to be seen from the RIP and 2 to 10 times more likely to be overtaken in the SOC by a MTB. The inherent safety risks are then 10 to 100 times greater.

Besides general float distances PSRs are also a function of the percentage of FC that are on the MTB route and the maneuvering options in the SOC available to the MTBs to avoid FC as well as site specific pop-out situations. On Table 3 the PSRs of Upper and Lower Galice can be compared based on these parameters for downstream operations at low flows. The PNS of Upper Galice is .313 and the PSR is .053 while for Lower Galice with a PNS of .346, the PSR is .468. The Lower Galice PNS is roughly comparable to that of Upper Galice while the PSR is about eight time greater. This is primarily the result of: 1) split FC routes in Upper Galice that, when considering the entire SOC length, expose much less than 100% of the FC to the MTBs; and 2) options within Upper Galice to stop a MTB and wait for FC ahead to clear the rapid as opposed to Lower Galice in which MTBs, once committed, need to run through the SOC on-plane. The PNS and PSR differences between these SOC/scenarios compound into ISR differences of about 10 times; .017 v. .162.

Table 3 shows that there are ISRs in all the SOCs except for Applegate, Two-Bit, and two scenarios of Ennis. For all other SOC/scenarios, based on the SOC Assessment assumptions, inadvertent potential accident situations can not be avoided. For the 56 SOC/scenarios associated with the 14 SOCs that have some level safety risk in at least one scenario, the ISRs range from less than .001 to .540 and average .159. On average for the whole study reach, when a MTB arrives at a SOC when a single FC is in the SOC, there is about a 16% chance that the FC will not be seen, the MTB will initiate a run, and a potential accident situation (MO) will develop. The average ISR for the 5 SOCs in the Scenic Section for all scenarios is .223 while for the 9 SOCs in the Whitewater Section the average ISR for all scenarios is .124. This indicates in general a greater level of inherent safety risk in the SOCs of the Scenic Section.

This finding is contrary to general FG input and the informal conclusions drawn by WRC during the field work. The field work interpretation that the Scenic Section SOCs were less hazardous was most likely due to the very low FC use levels and MTB/FC encounters observed on that reach and the resulting impression of low potential safety risks. The interpretation of possible frequency and likelihood of "inherent safety risk" situations from field observations were probably colored by the observed relatively high FC use levels in the Whitewater Section. SOC ISRs are based on physical characteristics and user patterns, not use levels.

Flow range has often been noted as a primary factor in modifying levels of safety risk in the Hellgate Study Reach with lower flows imparting higher safety risks (See section B: 1) above). SOC Assessment results both confirm and contradict various aspects of the general FG position of how flow magnitudes influence safety risks. Table 4A shows that for both MTB operational directions throughout the Hellgate Study Reach the average SOC/scenario ISR is .134 for high flow conditions and .184 for low flow conditions. The inherent safety risks are generally about 30% greater at low flows which conforms to the FG member input. However, when the two study reach sections are evaluated independently, low flow conditions increase ISRs by about 68% in the Scenic Section and only by about 13% in the Whitewater Section.

The finding that the SOCs of the Scenic Section are more safety-risk sensitive to streamflow magnitudes is contrary to the general perceptions presented by FG members and to the general conclusions drawn during field review by WRC. The variant field observations and user perception conclusions may result from a situation in which the greater FC use activity in Whitewater Section leads observers to conclude that greater levels of potential safety risk are induced by the differences in channel conditions. The contradictory results could also occur if the safe craft separation distance thresholds based on perceptions of acceptability adopted by the FG during workshop sessions, are different in some important aspect from those user perceptions of acceptable separation that may be applied on the river during an actual MTB/FC encounter. It may also be possible that actual on-river perceptions of safe craft separation distances are inverse to the perception of available maneuvering space with the perceived need for greater separation distances in the smaller, more confined channel in the Hellgate Section.

Further desegregating the information on Table 4A allows some inferences as to potential causes of these flow related differences. The average Scenic Section SOC ISR for downstream operations increase by 273% (.057 v. .212) at low flows

Table 3

SOC SAFETY RISK PARAMETERS
Hellgate Study Reach

	Downstream MTB Operations						Upstream MTB Operations					
	Low Flow			High Flow			Low Flow			High Flow		
SOCs	**PNS**	**PSR**	**ISR**	**PNS**	**PSR**	**ISR**	**PNS**	**PSR**	**ISR**	**PNS**	**PSR**	**ISR**
Scenic Section SOCs												
Middleton's Riffle	.429	.507	.218	.388	.064	.025	.437	.832	.364	.394	.890	.351
Applegate *	.000	.000	n/a	.000	.000	n/a	.000	.000	n/a	.000	.000	n/a
Whitehorse Riffle	.297	.843	.250	.297	.115	.034	.316	.796	.252	.316	.796	.252
Brushy Chutes	.586	.387	n/a	.491	.010	n/a	.409	.755	.309	.315	.530	.167
Pop-out		.069	n/a		.028	n/a						
Total		.456	.267		.038	.019						
Two Bit Riffle *	.000	.000	n/a	.000	.000	n/a	.000	.000	n/a	.000	.000	n/a
Hog Creek Island	.445	.418	.186	.328	.392	.129	.589	.916	.540	.589	.850	.501
Hellgate Riffle	.370	.334	n/a	.374	.207	.077	.342	.727	n/a	.210	.525	.110
Pop-out		.039	n/a					.046	n/a			
Total		.373	.138					.773	.264			
Average Sc SOCs	.425	.519	.212	.376	.163	.057	.419	.814	.346	.365	.718	.276
Average ISR for all Sc SOC/scenarios; .223												
Whitewater Section SOCs												
Dunn Riffle	.369	.073	.027	.369	.073	.027	.101	.513	.052	.101	.513	.052
Ennis Riffle	.000	.000	n/a	.000	.000	n/a	.100	.018	.002	.100	.018	.002
Upper Galice Chute	.313	.053	.017	.313	.053	.017	.776	.198	.154	.776	.198	.154
Pop-out		incl.			incl.							
Lower Galice Chute	.346	.468	.162	.346	.004	.001	.498	.879	.438	.498	.879	.438
Rocky Riffle	.377	.301	n/a	.377	.051	n/a	.415	.584	.242	.415	.584	.242
Pop-out		.026	n/a		.040	n/a						
Total		.327	.123		.091	.034						
Mark's Island	.268	.016	.004	.268	.016	.004	.417	.784	.327	.417	.784	.327
Bailey Riffle	.270	.562	.152	.270	.492	.133	.261	.766	.200	.261	.766	.203
Argo Riffle	.117	.198	.023	.117	.198	.023	.362	.889	.322	.362	.889	.322
Wooldridge Riffle	.038	.043	.002	.136	.002	<.001	.249	.470	.117	.249	.470	.117
Average WW SOCs	.233	.193	.057	.244	.103	.027	.353	.567	.206	.353	.567	.206
Average ISR for all WW SOC/scenarios; .124												
Average All SOCs	.302	.310	.112	.291	.125	.037	.377	.655	.256	.357	.621	.231
Average ISR for all SOC/scenarios; .159												

Notes: * SOCs with no ISR in any scenario are not included in averaged values.
Final safety risk parameters for 1992 conditions.

Table 4

SOC SAFETY RISK ASSESSMENT SUMMARY
BY STUDY REACH SECTION
Hellgate Study Reach

A. Compared by Flow Condition

Safety Risk Parameters*	Downstream Ops. High Flow	Downstream Ops. Low Flow	Downstream Ops. Delta (%)	Upstream Ops. High Flow	Upstream Ops. Low Flow	Upstream Ops. Delta (%)	Both Directions High Flow	Both Directions Low Flow	Both Directions Delta (%)
Scenic Section SOCs									
PNS	.376	.425	+13.3	.365	.419	+14.7	.370	.422	+14.0
PSR	.163	.519	+218.3	.718	.814	+13.4	.441	.667	+51.3
ISR	.057	.212	+273.4	.276	.346	+25.2	.166	.279	+67.5
Whitewater Section SOCs									
PNS	.244	.233	-4.5	.353	.353	nc	.299	.293	-1.8
PSR	.103	.193	+87.3	.567	.567	nc	.335	.380	+13.4
ISR	.027	.057	+111.1	.206	.206	nc	.116	.131	+12.9
Total Study Reach SOCs									
PNS	.291	.302	+3.7	.357	.377	+5.4	.324	.339	+4.6
PSR	.125	.310	+148.5	.621	.655	+5.5	.373	.483	+29.4
ISR	.037	.112	+199.7	.230	.256	+10.8	.134	.184	+37.1

B. Compared by MTB Operational Direction

Safety Risk Parameters*	Low Flow Down Ops.	Low Flow Up Ops.	Low Flow Diff. (%)	High Flow Down Ops.	High Flow Up Ops.	High Flow Diff. (%)
Scenic Section SOCs						
PNS	.425	.419	-1.6	.376	.365	-2.9
PSR	.519	.814	+56.8	.163	.718	+340.1
ISR	.212	.346	+63.1	.057	.276	+386.6
Whitewater Section SOCs						
PNS	.233	.353	+51.5	.244	.353	+44.8
PSR	.193	.567	+193.2	.103	.567	+449.1
ISR	.057	.206	+263.7	.027	.206	+672.8
Total Study Reach SOCs						
PNS	.302	.377	+24.8	.291	.357	+22.8
PSR	.310	.655	+111.5	.125	.621	+398.1
ISR	.112	.256	+128.3	.037	.231	+517.1

Notes: * Final safety risk parameters and 1992 conditions. All values are averages for the SOCs and scenario conditions referenced; SOCs with no ISR in any scenario are not included in averaged values (See Table 3).

primarily due to a 218% increase in average SOC PSR along with a small increase in PNS. Average low flow SOC ISR for upstream operations in the Scenic Section increase by only about 25%. For those Scenic Section SOC/scenarios with the largest increase in ISRs, the major factor was reduced MTB drifting options during downstream operations and changed set-down threshold locations for upstream operations (See SOC Assessment Plates). When MTB drifting options were not present, MTBs had a faster run time through SOCs and had a greater chance of overtaking FC. Low flow conditions in Whitewater Section SOCs increase the average ISR for downstream operations by about 111% resulting from a 87% increase in PSR while PNS dropped by 4.5%. These increases result from changes at only 4 SOCs in which MTB drifting options were unavailable at lower flows. There was no change in average ISR for the upstream operational direction in the Whitewater Section because set-down areas and set-down threshold locations remain basically unchanged.

A review of Table 4A and the SOC Assessment Plates indicates that the relative insensitivity of inherent safety risks in the Whitewater Section to flow magnitudes was due to essentially no change in MTB operational limitations and options at the two flow levels. The generally narrower channel and the prevalence of bedrock channel controls in this section leads to more pronounced channel bottom topography and well defined pools. Little change in set-down threshold locations occur between the flow ranges under consideration here. This means that the RIPs and STs remain in essentially the same locations and therefore so do LOS thresholds. In addition based on the assumed safe craft separation distances, larger effective channel areas at higher flows were not great enough to change the MO circumstances of the MTB/FC encounters. This leads to similar safety risk conditions between the flows. The consistency of MTB operational options between flow range conditions in the Whitewater Section was particularly evident for upstream operations where the SOC Assessments resulted in no ISR difference between high and low flow conditions for any of the SOCs. For upstream operations there were no changes in LOS thresholds, MTB stopping options, nor pop-out situations in the Whitewater Section. Conversely, wider channel conditions in the Scenic Section result in more gentle bottom topography and therefore greater shifts in set-down threshold location with streamflow. Under high flow conditions, Scenic Section SOCs generally became shorter, the LOS thresholds were located further into the SOCs and shadow areas shrunk, and there were often greater stopping and drifting options available to MTBs.

Safety risks in SOCs vary with MTB operational directions as well. When MTBs are running SOCs in the downstream direction the MOs that can occur include MTBs either on or off-plane, overtaking FC before they float to the defined safety threshold at the end of the SOC, and pop-outs when MTBs pass locations of FC activities that were not related to running directly through the SOC. When MTBs were traveling upstream through SOCs, MOs include encountering approaching FC on-plane, pop-outs from behind rocks or other visual screening features at close range, and float-bys when FC approach stopped MTBs in narrow, turbulent set-down areas.

The MTB and pvt-JB operator as well as FC user members of the FG have repeatedly stated that upstream operations are safer than downstream operations (Appendix K, 63-4, 66). Perceptions of upstream operational safety was due to greater JB operator comfort in getting a JB off-plane and stopped when going upstream into the current; they can idle into the current and hold a steady position. Conversely when operating downstream with the current, totally stopping the JB requires turning the craft around and heading upstream into the current. While upstream operational set-down areas can be fairly small, downstream operational set-down areas need to be longer and wider to be useful. Some downstream set-down areas can be used effectively to stop a JB but they may be too short to allow the JB to get back on-plane before reaching a drift-limiting channel section. In addition to stopping JBs, there are circumstances that allow downstream operating JBs to get off-plane but not to stop and the JB can negotiate the rest of a SOC in an off-plane drifting mode. While safer than running on-plane with FC, from the perspective of JB safety and FC safety, drifting in an SOC is considerably less desirable than stopping.

Table 4B indicates that, contrary to the impression of JB and FC operators, downstream MTB operations are consistently safer than upstream operations. The 28 downstream operational SOC/scenarios (both flow ranges) have an average ISR of .075 (.112 and .037) while the average ISR for the upstream operational SOC/scenarios is .244 (.256 and .231); about 3 times greater. While it is true that stopping a JB going upstream is easier, two factors make it less safe in the SOCs: 1) if an

set-down area, in-floating FC can continue to create MOs; and, 2) because of line of sight issues, no matter how long a lead MTB waits before initiating the upstream run, knowledge of FC activity above the LOS threshold does not improve and MOs can occur on each MTB run regardless of apparent clearance.

The upstream ISRs in the Scenic Section are 63 and 387% greater than downstream operations for low and high flow conditions respectively. The greater ISR directional difference under high flow conditions results from a large PSR reduction for downstream operations at high flows. This leads to a large reduction in downstream ISRs at high flows and thus a large percentage difference between downstream and upstream operational directions at high flows. The large change in downstream operational average ISR is primarily due to the increased downstream MTB drifting options at some SOCs at high flows.

Similarly, in the Whitewater Section reduced downstream ISRs at high flows results in a greater operational direction ISR disparity between low and high flow conditions even though upstream operational ISRs are unchanged by flows. With a 47% reduction in downstream ISRs at high flows (.057 v. .027) the ISRs for upstream operations are 264 and 673% greater than downstream operations for low and high flow conditions respectively.

In spite of the findings of safety risk potential at SOCs, MTB operators, pvt-JB operators, and the frequent commercial sector FC user members of the FG have expressed high degrees of comfort with MTB uses in SOCs. Conversely other FC and bed and bank users and the infrequent non-commercial sector FC user members of the FG expressed BS/C discomfort with MTB uses in SOCs and non-SOC areas of the study reach (See Appendix K; Focus Group Meeting Notes for details). As a result of on-river observations at SOCs during the 1992 field season, the assessment of FC user patterns, and the SOC Assessment process, some observations can be made as to the reasons for the discrepancy between the SOC Assessment results and the opinions of experienced users.

1: During downstream operations, MTB operators and many experienced FC users often rely on the ability to observe the entrance to SOCs from a considerable SOC approach distance as a measure of the likelihood that the SOC will be empty of FC when the MTBs arrive at the RIP (ibid., 64). The SOC Assessments indicate the they may overestimate the effectiveness of the approach visibilities. The entrance areas of some SOCs can be observed for over a minute during a MTB approach and often the duration of approach visibility is extended purposefully by stopping above the SOC for interpretative talks by the operator. With these relatively long approach visibility times, operators assume that any FC that may be in the SOC which were not observed have the opportunity to float on through the SOC prior to the MTB entrance. The SOC Assessment part of the evaluation included the determination of the most critical SOC visibility point for approaching MTBs. In most cases during downstream MTB operations, the MTB speeds through the approach visibility area are so fast, relative to the float speeds of FC in the SOCs, that by the time the MTBs reach the RIPs some FC can be visually overtaken. That is, FC that may have been just out of sight from the start of the approach visibility area can be seen from the RIPs and the approach visibility does not reduce the PNSs, PSRs, nor the ISRs. This is even true at Hog Creek Island where the MTBs in addition to a very long approach time, typically exercise about a 3 minute interpretative stop to provide additional time for FC to float through the SOC. This overconfidence in the effectiveness of the approach visibility is most likely due to a mistaken perception of the relative FC/MTB speeds and how long it takes typical FC observed in a SOC, to float through the SOC to a safe location.

2: MTB operators may tend to overestimate their RIP view fields. In many SOCs, particularly in long SOCs with gradual turns MTB operators are unaware that their field of view from RIPs do not extend through to locations where safe stops can be executed. Upper Galice during upstream operations is a good example. The MTB operator member of the FG stated that from the RIP the view field is through to about the base of Carpenter's Island but careful field and aerial photo verification by WRC of the LOS indicted that the LOS threshold crossed the main FC route about 380 feet closer to the RIP (ibid., 64 and Plate 46). This LOS threshold difference is the difference between portions of the main eddy in Upper Galice being or not being visible from the RIP; a significant difference with respect to ISRs. Similarly in downstream operations at Upper Galice, the MTB operator member of the FG maintained that

MTB operators can observe the entire lower portion of the SOC from the main eddy where the MTB can stop to accommodate FC users that may be in the main chute. WRC's field work showed that even from a assumed eye-height of the operator (8-10 ft.), the pop-out risk area in the tailwater cannot be seen. In addition field work showed that only a small portion of the main eddy can be seen from the RIP at the top of Carpenter's Island, therefore MTBs enter the main eddy area with only partial FC occupation information. Problems such as these may lead to a false sense of security when initiating MTB runs through SOCs. In several situations this problem is further evidenced by the location of vegetation trimmed by MTB operators to improve visibility. When carefully reviewed by ground truthing the field of view, some of these vegetated areas had no influence on screening.

3: When operating upstream, MTB operators may tend to underestimate the rate at which FC can enter a safe MTB stopping point from unseen areas even when that set-down area is visible from the RIP. During a 30 sec. MTB run from a RIP, FC that were not visible from the RIP can float from 150 to over 300 feet downstream and enter the set-down location before the MTB reaches it. It appears that this relationship is recognized by neither MTB operators nor experienced FC users.

4: MTB operators overestimate the ability to stop the MTBs from on-plane speeds. During many user/operator interviews it was repeatedly stated that JBs and MTBs can stop in 1 to 2 boat lengths. MTB stop tests on "Medium" sized MTBs showed that it generally takes 3 boat lengths to reach a drifting attitude and 4 boat lengths to fully stop using a straight line maneuver (See Figure 8). When reaction time, MTB footprint, and safe craft separation distance are incorporated, stopping to drift can be 4 boat lengths and 5 boat lengths may be required to fully stop (See Figures 9 and 10). In addition MTB operators may assume that any emergency stop that they will have to undertake will involve only one FC which would allow the option to use the entire effective channel for stopping and provide options for passing stops or turning stops. The occupation of SOCs by multiple FC could require the use of straight-line stopping or using a maneuvering stop that may endanger the safety of the MTB craft and/or passengers. In the BS/C Study maneuvering stops that can be used to avoid MTB/FC MO encounters was also considered a MO situation because the MTB craft and/or passengers may be endangered. MTB and FC operators may not perceived this safety risk aspect as being part of the MTB/FC encounter MO.

5: The present (1992) FC user pattern was notable for its very spiky and clumped distribution. This results in short periods when a SOC can have 10-20 or more FC per 15-minute interval followed by longer periods (one to five 15-minute intervals) of very little or no FC activity (See Figure 4A). The long-termed 3-point running average approach used in the FC Use Distribution Model largely overrides the spiky FC user patterns that typically occur during a particular recreation day (See Figures 4A and 4B). The short-termed spiky pattern results in MTBs often running SOCs with little or no FC activity when only minutes before or seconds before, FC were occupying portions of the SOC that could have put them at risk. Neither FC users nor the MTB operators involved were observed to be aware of how close they each were to being involved in potentially accident situations. While these situations were observed repeatedly by the WRC field team throughout the field season at many SOCs, the random timing of activities usually resulted in potential accident situations being avoided, often by very small time intervals. These near MO situations were seen only because SOCs were under observation continuously for extended periods of time through the sample days. Pop-out and upstream operational LOS thresholds were situations particularly sensitive to influence of random FC and MTB timing on the incidence of MOs. Neither MTB operators nor FC users spend protracted periods of time at specific SOCs observing these situations and are therefore mostly unaware of the frequency with which potential accident situations are narrowly avoided. Due to the lack of appreciation for the significance of activity timing and the frequency at which potentially serious FC/MTB encounters have been narrowly avoided may lead all parties to a perceptive underestimation of the potential BS/C concerns.

6. All of the craft separation distance thresholds, as they were applied in the SOC Assessments, assumed multi-FC situations. The straight-line stopping SSDs assumed that in every situation multi-FC are present and MTBs were prohibited from using safe evasive maneuvers to avoid MOs, and

Figure 33

HELLGATE RIFFLE

An on-plane upstream operating "Medium" sized MTB in Hellgate Canyon approaching Sentinel Rock under low flow conditions. The MTB is located between Point B and the RIP at Point C on Plate 30. View into Hellgate Riffle past Sentinel Rock is between LOS E and D and the MTB operator has just obtained a complete view of the swift water portion and part of the tongue of the RL FC route. From this location the entire RR FC route is unseen along with the face of Sentinel Rock and much of the tongue that leads to the RL route.

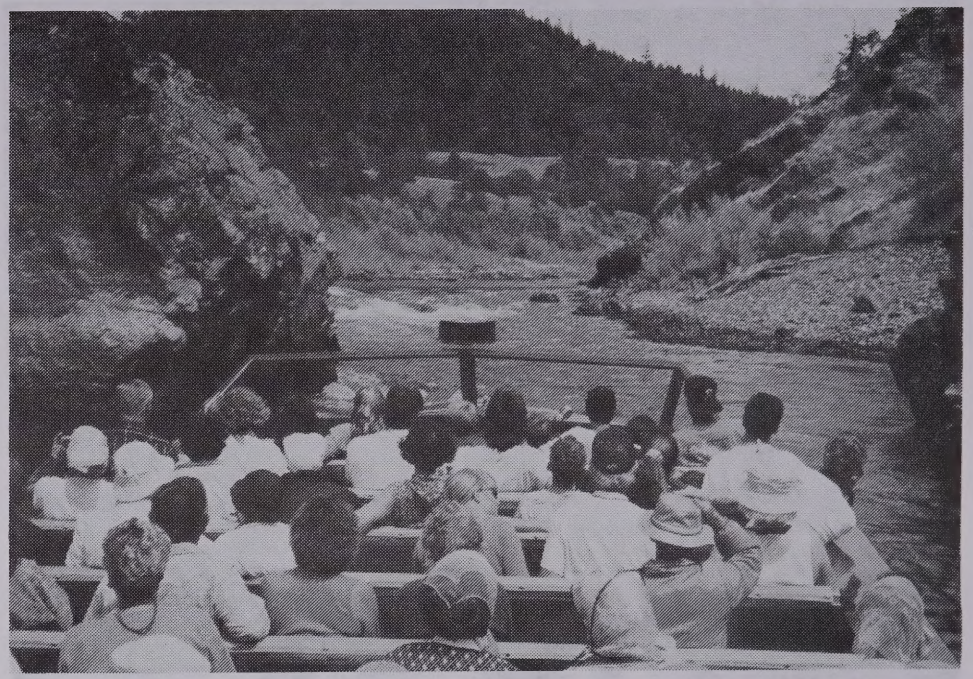


Figure 34

HELLGATE RIFFLE

An on-plane upstream operating "Large" sized MTB in Hellgate Canyon approaching Sentinel Rock under low flow conditions. The MTB is at about the RIP at Point C on Plate 30. View into Hellgate Riffle is along about LOS D. The MTB operator has just obtained the first full view of the RL FC route tongue and the whitewater portion of the RR route. The RR route tailwater and the face of Sentinel Rock are unseen from this point and the glide above the tongue and the MTB stopping location at Point G are not yet fully visible. First view of part of the RR FC route has just been obtained by the MTB operator. The point of the pop-out safety risk at the face of Sentinel Rock is the RL edge of Sentinel Rock in the center of the left windshield in this photo. An on-plane MTB at this position would not be able to stop if a FC pop-out occurs at Sentinel Rock and would have no room to safely avoid FC or swimmers (note bedrock bank on RL).

Figure 35

HELLGATE RIFFLE

An on-plane upstream operating "Medium" sized MTB passing Sentinel Rock (to the left of the windshield) under low flow conditions. The MTB is about even with Sentinel Rock and is just past Point C on Plate 30. View into Hellgate Riffle is slightly better than along LOS D. First view of most of the RR FC route has just been obtained by the MTB operator. FC coming off the face of Sentinel Rock are still unseen. An on-plane MTB at this position would not be able to safely stop if a FC pop-out occurs at Sentinel Rock.

Figure 36

ARGO RIFFLE

An on-plane upstream operating "Medium" sized MTB just past the RIP on Plate 63. The MTB is at its RL most view location and the view into Argo Riffle is slightly better than that along LOS B. From this location the MTB operator can not see any of the glide and tongue area (See Figure 25), nor much of the RR FC route through the first portion of the rapid. The MTB route from here is along the RR wall (left side of photo) and views do not improve until the MTB operator approaches the apex of the bedrock turn about half way through the run (about 150 ft. upstream of Point C, Plate 63). Any FC above the LOS threshold from this MTB position are at potential risk.

Figure 37

HOG CREEK ISLAND

An on-plane upstream operating "Large" sized MTB under low flow conditions located at about the origin point of LOS D on Plate 25 and the view into Hog Creek Island is along LOS D. The set-down area of Point O is first visible from this point but any FC in the set-down or above it would be a MO situation due to water velocity, turbulence and set-down area narrowness. MTB operator can not see upstream of the tailwater hydraulics created by the bedrock knobs and the bedrock RR bank. From this location under high flow conditions the MTB operator can see Point K on Plate 26 but not the RL FC float route above Point K.

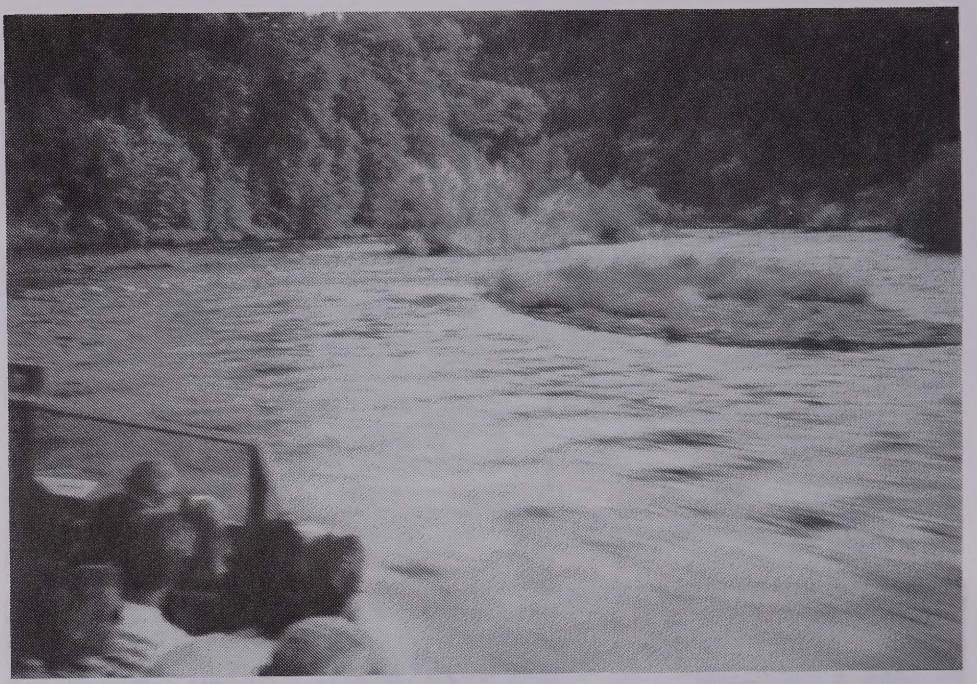


Figure 38

HOG CREEK ISLAND

An on-plane upstream operating "Medium" sized MTB under high flow conditions located at about Point B on Plate 25. The MTB operator at this point is in the middle of a rotating view to the top of the main island (center of the photo). The view up the RL channel is just past LOS L, view up the RR channel is just before LOS M. MTBs can stop in flat water in the RR channel adjacent to the main island and avoid MOs.

Figure 39

HOG CREEK ISLAND

An on-plane upstream operating "Large" sized MTB under low flow conditions located at about ST1 on Plate 25. This is an usable set-down area for upstream operating MTBs; there is enough room and hydraulics are calm enough to assure that a stopped MTB can avoid MOs with multi-FC. From this location the view upstream is to about the distal end of LOS L. The area above this point was visible from Point N along LOS L (See Figure 38). If a MTB stops at this location to accommodate FC it can idle up to the riffle drop to check the pool area above the island to assure FC absence before re-initiating the run.

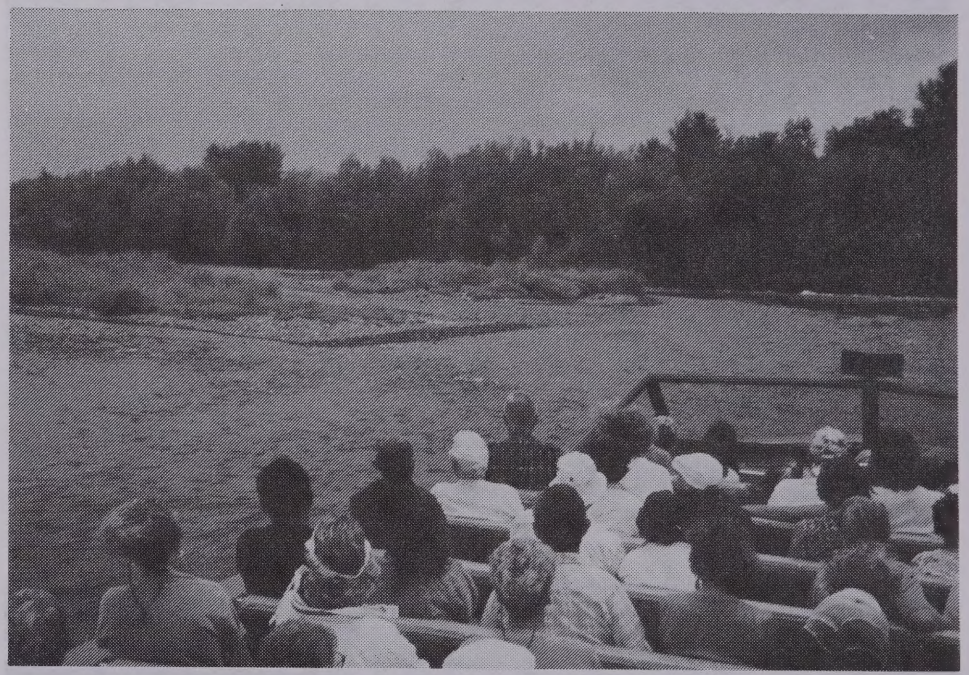


Figure 40

WHITEHORSE RIFFLE

An on-plane upstream operating "Large" sized MTB between Point C and the RIP at Point D on Plate 12 under low flow conditions. View at about 10 o'clock to the craft axis is between the islands roughly along LOSs E and G on Plate 12. This view from the MTB operator position clearly shows that FC in the main route next the low vegetated island marked "L" on Plate 12, can not be seen from the RIP nor on the approach to the RIP. By the time the MTB operator reaches the RIP position (about where the bow is located in this photo) in about 1.5 secs., the MTB will be committed to running the SOC. These low vegetated bars and islands create additional LOS problems for Pvt-JB operators with lower eye level positions.

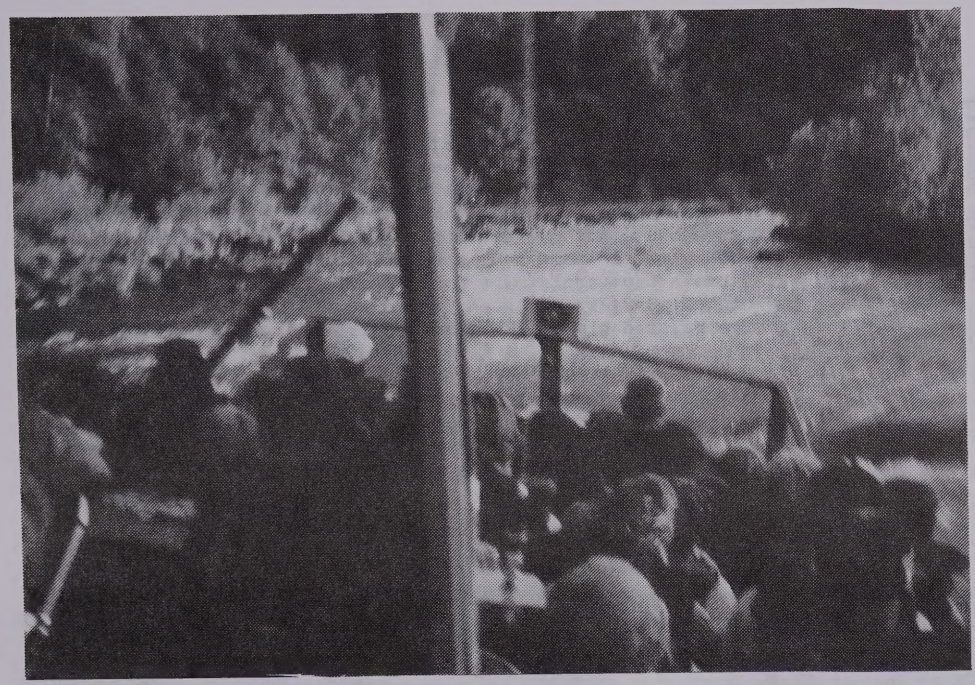


Figure 41

LOWER GALICE CHUTE

An on-plane upstream operating "Medium" sized MTB passing the RIP at Point A on Plate 51 under high flow conditions. The view into Lower Galice Chute is along LOS B. From this location the MTB operator can not see the glide, the tongue, nor the upstream portions of either the RR or RL FC routes in the rapid. The MTB route from here is to the RR of the bedrock ledge to the center of the channel. Once in the rapid and above the bedrock ledge (about 170 ft. above Point C, Plate 51) and in the whitewater portion of the rapid the MTB operator can see to the RR FC route tongue and glide area but only part of the RL FC route. Any MTB/FC encounter in this SOC is a MO situation because of the hydraulic turbulence and narrowness of the channel.

Figure 42

BRUSHY CHUTES

An on-plane upstream operating "Large" sized MTB passing the RIP just before Point B on Plate 18 under high flow conditions. At this location the view into Brushy Chutes is just short of LOS C and the extreme RL edge of the set-down area at G is just coming into view to the MTB operator. Nearly all of the possible FC locations between Points G and H (Plate 18) are not visible to the MTB operator and could be involved in MOs.

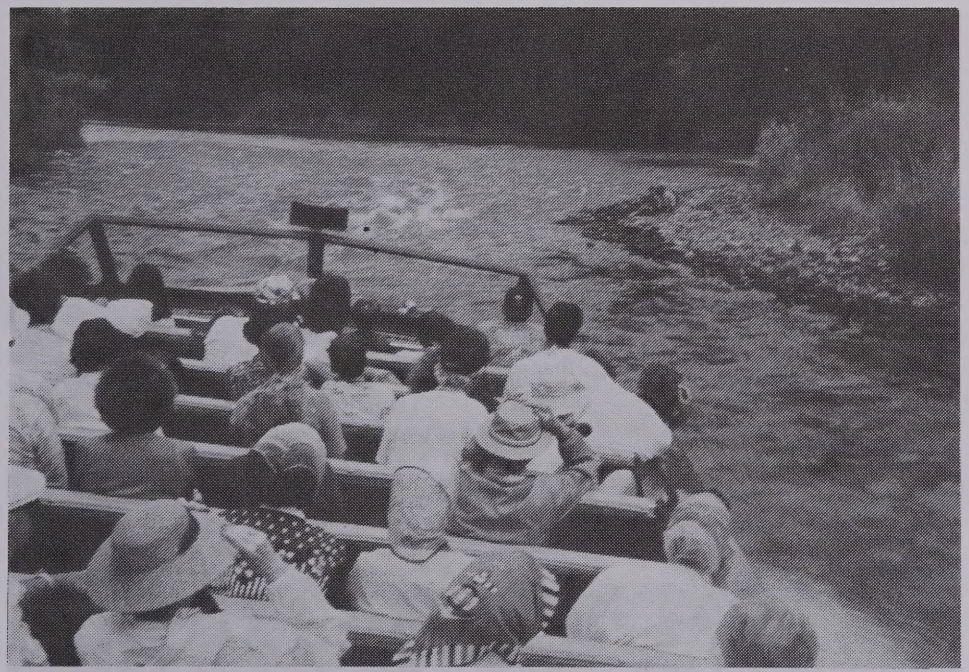


Figure 43

DEADMAN'S ISLAND

An on-plane upstream operating "Large" sized MTB passing a bank user at this riffle. The flat water above the glide is large enough and far enough below the LOS threshold that, should a FC float into view at the LOS threshold after the MTB run has been initiated, the MTB can reach the ST area and stop above the riffle before any FC could float to a position that could create a MO. Short, steep riffle drops near Grants Pass like this are favorite skim-board sites for adolescents and preadolescents. The frequency of MTB passes through these areas has probably dislocated skim-boarders to other river and non-river pursuits.

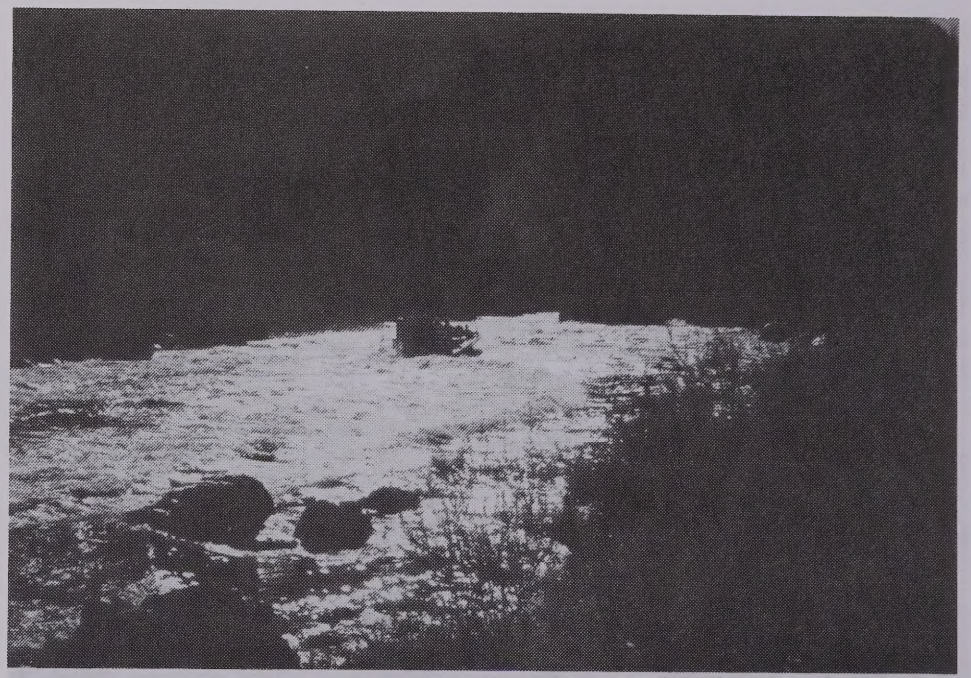


Figure 44

GLARE

Photograph indicating the additional safety risk potential induced by glare on the Hellgate Study Reach. Glare was observed to be most important when the sun was less than about 45 degrees high and within about 15 degrees of the line of sight. SOCs on the Hellgate Study Reach where glare was noted as an additional safety risk issues included; Hellgate Riffle on the downstream leg of Dinner trips (shown in this photo), Rocky Riffle on the upstream leg of PM Whitewater trips, and Bailey Riffle on the upstream leg of AM Whitewater trips. Glare was also observed to increase the safety risk factor in some non-SOC areas such as the approach to the bottom of Brushy Chute in the late afternoon hours.

passing safe craft separation thresholds assumed that multi-FC needed to be avoided to prevent MOs. While it was recognized during the field work that most potential MTB/FC encounters would involve a single FC, the safety aggravating aspect of multi-FC involvement was seen as particularly severe. The FC and JB operator members of the FG also noted the special safety problems associated with multi-FC encounters (ibid., 58, 58-9, 84). With the SOC Assessment safety thresholds set by multi-FC situations very often MTB/FC encounters could occur involving single FC with enough room to avoid MOs while multi-FC situations would create MOs. Under the present FC user patterns single-FC situations are far more common and many of the MO encounters that result from the Multi-FC SOC Assessments and the SR/C Model would not be interpreted as MOs in the field. The much more common single-FC encounter situation, in which MOs are potentially avoidable, provides the perception of safety and allows users to ignore the potential safety hazards associated with multi-FC in the same encounter situation.

7. Because of the foregoing clumped FC use distribution, present FC use patterns in SOCs, and the present FC use levels, when MTBs approach SOCs and no FC are observed it is very much more likely that no FC are present and, when they are present, most are single-FC encounters. This results in repetitive MTB runs in which no MTB/FC MO encounters occur. Repetitive success (no MOs) instills a sense, on the part of JB operators and very frequent FC users, that safety is the rule and leads to the ignorance of those very particular situations in which MOs could result. Due to the relative infrequency of accidents and recognized accident situations, attitudes of relative safety were held by the JB operator and the commercial FC operator members of the FG while concern as to safety were expressed by the infrequent FC users and bed/bank user members of the FG.

The fundamental result of the SOC Assessments was that at nearly all SOCs for all scenarios, using the best skills and most prudent judgement, MTBs can not be operated in such a way as to avoid involvement in incidents that have the potential to lead to accidents. This is not to say that in all circumstances MTBs are the cause of the potential accident situations but in accordance with the basic SOC Assessment fault-tree risk approach assumptions, the MTB operator uses view fields, knowledge fields, and best and most prudent judgement to determine MTB operations in SOCs, and uses best operator skills and MTB craft operating characteristics to prevent MTB/FC encounters in SOCs from evolving into MO conditions. Therefore FC were assumed to be passive components of the safety risk scenarios. When all aspects of channel characteristics were considered along with MTB operations, MTB SSDs, and FC user patterns, etc., the occurrence of MTB/FC MO encounters in SOCs were outside the control of MTB operators. Once MTB runs are initiated into these SOCs, MOs can occur as a function of user levels and the random timing of activities in the SOCs. In each of these SOCs with each lead MTB run, it is merely a chance probability that MTB/FC MO encounters will occur.

A basic tenet of river recreation boating safety is that when no safe stopping point is within the field of view it is unsafe to proceed into sections of a river where unknown hazardous circumstances may exist. This provides river boaters with a margin of safety that allows them to avoid having to proceed into potentially hazardous sections where the ability to safely abort the run may not exist. The SOC Assessments of the Hellgate Study Reach SOCs indicate that within the resolution capacity of the fault-tree risk assessment approach, MTBs do not have that margin of safety. The margin referred to here is that which allows operators to avoid inadvertently creating potential accident situations not necessarily the margins of safety needed to avoid accidents once the accident situation has occurred. By definition a MO is an inadvertent (when best MTB operator skill and judgement is applied) MTB/FC encounter in a SOC that results in less than adopted safe craft separation threshold distances. Therefore each MO incident is an unavoidable incident that can, but not necessarily will, lead to an accident.

Within a particular MO situation, the circumstances that may or may not lead to an actual accident are driven not only by operator skill and craft operational characteristics but also by very small margins of craft position and the incidental timing of activities. Craft position and timing factors are fundamentally random and not subject to precise predictability. These spatial and temporal factors can be very subtle, with tolerances on the order of a few feet or seconds, and can be a result of random chance of occurrences and conditions. Should an accident occur, the same range of circumstances and randomness of conditions can drive the outcome severity of the accident. Within a specific MO situation the difference between an accident with loss of life severity and no accident at all can result from

circumstantial differences as small as the location of a FC or a MTB by 2 feet, a momentary reduction in visibility due to glare, or 2 second's worth of float position in the SOC.

The factors that lead from MO situations to accidents, and from accidents to equipment damage, injury, or loss of life severity include a multitude of timing, craft positioning, and operator responses, etc., that are impossible to predict using risk modeling techniques. Therefore the resolution of the BS/C safety risk assessment is limited to the prediction of MOs. Because the channel conditions of the SOC/scenarios provide the opportunity for MTB operators to inadvertently place MTBs in MO situations and because the accident outcome of MOs are circumstantial and problematical, each MO situation is characterized here as an "unsafe" situation. When MTBs run into portions of SOCs outside of the view and/or knowledge fields, each and every lead MTB run includes new and different FC conditions. Lead MTBs could encounter FC in different numbers, in different locations, and operated at different speeds and patterns. Some combinations of these elements, in conjunction with MTB characteristics and MTB operator skill and judgement levels could lead to accidents.

By contrast, a "safe" situation would be characterized by channel conditions that allow MTB operators to proceed throughout the trip itinerary from one safe stopping location to the next with view fields that are adequate to prohibit "inadvertent" commitments to situations that could evolve to accidents. "Safe" conditions are those that eliminate the "inadvertent" parameter and limit potential accidents to those that may result from poor operator skill, imprudent judgement, human error, and equipment failure, etc. These are the factors that are potential accident parameters in all river recreation settings.

The importance to safety of adequate visual access between sequential MTB safe stopping locations was demonstrated in part by the MTB owner/operator's program of vegetation control and trimming at various SOCs. This activity improves visual access at many of these locations but during the field review and the SOC Assessment effort it was found to fall short of eliminating visual screening at any SOC and did not reduce the ISRs to zero. In addition the MTB operator and pvt-JB operator members of the FG stated throughout the study process that visibility 'is the key' (Appendix K, 121, 136, 137) and where complete visual access to the next safe stopping locations did not exist, the JB operators recognized that MO situations can result (ibid., 108, 153). To avoid accidents in these situations MTB operators rely on MTB maneuvering options (ibid., 86) and/or assume that FC operators will hear on-coming MTBs and will accommodate MTBs by moving correctly to safe positions (ibid., 108).

MO situations in the SOC/scenarios vary in likelihood of occurrence and potential severity. The PMOs predicted for each SOC/scenario are the same as the ISRs on Table 3. As can be seen in the table the PMOs in some SOC/scenarios are extremely small, less than 0.1% (<.001), such as for downstream operations at Wooldridge, while in others it can be relatively high, 54% (.540), such as for upstream at Hog Creek Islands. Of the 14 SOCs that have some level of ISR, 20 SOC/scenarios have PMOs of less than 5%, 17 have PMOs of over 25%, and the average PMO is 16.3%. Given these PMOs and the number of MTB trips that can be conducted in a typical MRS (about 530), it would seem that many MO situations would occur each year and that the MOs would be evidenced by reports of accident occurrences. The apparent low number of reported accidents on the study reach in the past does not necessarily argue against the conclusion that PMOs can be relatively high.

There are several reasons that reported accidents are not as common as the ISRs and PMOs may imply. First, it should be remembered that PMOs and ISRs predict MOs - potential accident situations - not accidents, therefore MO incidents are not subject to accident reporting requirements. Second, accidents narrowly avoided due to evasive maneuvers, etc., are not accidents and are not subject to accident reporting requirements.

Third, the safe craft separation threshold distances were developed for multi-FC situations. For some circumstances the multi-FC distance thresholds that result in the need for effective channel areas to be wide enough to allow one MTB to safely pass two FC in the worst possible configuration (one on each side of the MTB) before a MO is avoided. The present FC use patterns, however, indicate that the majority of those potential MO situations that actually occur will involve only a single FC at the point of encounter. In these cases the SOC Assessments and the SR/C Model may have predicted MO situations but there could very well be enough available space to allow for single-FC/MTB encounters at less than real MO

circumstances. This does not invalidate the BS/C safety risk modeling approach and the SR/C Model results because in each MO situation multi-FC circumstances are possible and Multi-FC Assessment approaches are necessary to accommodate these circumstances to assure that a "non-MO" model result really represents a safe situation.

Fourth, as explained above, the present daily FC user distribution pattern at a given SOC was much more variable and spiky than that which was portrayed on the UUCs. The long-termed three-point running average manipulation does not reflect the actual random distribution of FC that a MTB may encounter on a single given day at a given SOC RIP. An example of actual short-term FC distribution pattern can be seen in Figure 4 where FC occupation of the SOC pegs wildly from zero for extended periods of time to very high peak values for shorter periods of time. This results in arriving MTBs most often experiencing either no FC in the SOC which allows a safe run, or enough FC in the SOC to prevent the MTB run from being initiated; also a safe situation. Relative to the actual number of FC that an arriving MTB may encounter at a SOC, the 3-point average used in the UUCs to generate the predicted MOs in the SR/C Model tends to overpredict the frequencies of low (but not zero) FC numbers. These low FC numbers are more likely to result in a situation in which all occupying FC are unseen from the RIP which would lead to higher MO prediction. Therefore the MOs predicted for a typical MRS are probably artificially high which may lead to a higher expectation of accident outcomes. (See Chapter V for other modeling limitations.

Finally, there is a record of MO incidents, accidents, and near accidents that indicates the importance of visual screening and safe stopping on MO situations and the close relationship between MOs and accidents (See Appendix A; River Incident Evaluation for details). In September 1991 at Applegate, a downstream operating "Large" sized MTB passed its RIP (as would be defined by "Large" MTB SSDs and the actual approach speed) before the operator could observe that the lower set-down area was occupied by a driftboat. In the process of evasive maneuvering by the MTB operator to avoid a MO or an accident with the FC, the MTB was piloted into an area that had no set-down option and, in an on-plane mode, the MTB hit the channel bank during a high speed turn. This was an MO situation that resulted in an accident as defined by the FG (reported minor injuries and the potential for equipment and major injury or even loss of life). When the Applegate site was reviewed in the SOC Assessment step there were no ISRs for any of the SOC/scenarios because "Medium" sized MTBs traveling at 25 mph had SSDs that allowed operators to view the lower set-down area before passing their RIP. Under these conditions the site would not limit safe MTB operations and would not be considered as a SOC. However, it appears that Applegate is a SOC with some level of ISR when "Large" sized MTBs are the lead craft and/or when MTBs are travelling too fast to use the assumed SSDs in the MO prediction. MOs, accidents and near accidents have also occurred: 1) at Hellgate in July 1992, when a downstream operating MTB passed a swimmer from a capsized FC at very close range in very tight maneuvering conditions; 2) at Upper Galice in July 1991, when a downstream operating pvt-JB was co-occupying the main chute area with other FC and was unable to stop reportedly because of equipment failure; and, 3) in Upper Galice in May 1985, when a downstream operating MTB was co-occupying the main chute area with other FC because the main eddy, used by JBs to stop in the SOC, was occupied by other FC. Each of these incidents are examples of MOs that were potential accident situations. They were probably not the result of operator errors in the strictest sense, but rather of limited visual access into the SOCs that induced JB runs when FC were unseen but were in potentially risky circumstances.

Besides the probability of MOs occurring at SOCs, "safe" and "unsafe" conditions are driven by the possibility of MOs evolving into accidents and the potential severity of any actual accident. Similar to the wide range of PMOs for the various SOC/scenarios, the MO situations in the SOC/scenarios have a wide range of actual accident occurrence potential and possible accident outcome severity. These two parameters are discussed in greater detail in Appendix H; SOC Hazard Severity Rating. Some MO situations have very small possibilities of evolving into actual accidents, and should an accident occur, result in relatively low degrees of outcome severity. These are typically MOs in set-down areas that are wide and/or quite where MTB/FC encounters would result in MOs but provide the circumstances that allow accidents to be avoided with a relatively high level of assurance.

Conversely, other SOC MO situations involve circumstances that make it much more likely that accidents will evolve and that accidents, should they occur, could involve very severe outcomes including even the loss of life. These MOs are typically situations in which the MTBs are on-plane passing LOS thresholds and pop-out locations where the visual thresholds are very close to the MTB, where the

operators have very short reaction times and very limited operating room. While these MOs are likely to evolve into accidents with possibly severe outcomes, they are most often dependent on very precise timing and location circumstances which can have a very low probability of occurring; low PMOs.

The BS/C Study finding that under 1992 channel conditions and for the assumed SSDs of the "Medium" sized MTBs most of the SOC/scenarios reviewed are not safe, does not address the issue of acceptable risk. The criteria for "safe" circumstances, as used above, is an ISR of zero. Anything short of that condition implies accident potentials above and beyond those associated with normal powerboat operations on rivers with good visibility and operational options. Acceptable risk is a management decision that incorporates many other issues such as resource values, visitation options, economic benefits, etc., and the "probability" aspects of safety risk to determine an appropriate degree of safety risk exposure. Acceptable risk is an issue that may be addressed in BLM's RAMP process.

b) Pvt-JB - SOC Probability of Risk; The SOC Assessments were based on the PSDs for "Medium" sized MTBs and the observed MTB operating patterns through the SOCs. Specific stop test were not conducted on pvt-JBs but casual on-river observations indicate that SSDs can be as short as 40-60 ft. for these craft. This is due to several craft related characteristics: 1) very low weight and inertia; 2) high power to weight ratios for high performance JBs (See Figure 12); 3) very slow on-plane speeds for low performance fishing sled type JBs (See Figure 11); and 4) the ability to preform tight evasive stopping maneuvers in emergency situations with little safety risk to the JB craft and passengers.

Although not specifically modeled, shorter SSDs and often lower operating speeds for these craft would lead to many modified SOC Assessment safety risk results. The shorter SSDs allow RIPs to be closer to the set-down threshold at the entrance to SOCs and STs closer to the set-down threshold at the end of SOCs. This provides for shorter SOC lengths and reduced PROs. Shorter SSDs also reduce the minimum length of usable set-downs and make more set-down areas within SOCs available for safe operational stops. This reduces the calculated PSRs and the reduced PROs and PSRs result in reduced PMOs, and therefore the ISRs, for any given level of FC uses. From the observed characteristics of the SOCs, the use of the pvt-JBs should lead to reduced ISRs in nearly all SOC/scenarios relative to MTBs.

The operator's eye position in the pvt-JBs are generally much lower (about 4-6 ft. above the water) than that for MTB operators (about 8-10+ ft. above the water) and in certain circumstance may lead to a reduced view fields at SOC RIPs. This possibility occurs mostly during downstream operations at locations where a low vegetated bar is on the inside of a turn. The low pvt-JB operator eye height leads to greater unseen areas below the vegetated bars when compared to the shadow zones for MTB operators. The screening effect of these bars are exacerbated at low flows because the water surface elevation at the heads of pools and runs (located just below these bars) are more sensitive to flow magnitude changes than is the water surface at the heads of riffles (located just above these bars) (See Appendix K; Focus Group Meeting Notes, 93, 148). The greater elevation difference in water surface above and below these bars at lower flows increases the LOS screening potential of low vegetated bars. The only SOCs where this factor may presently lead to greater PSRs for pvt-JBs are Whitehorse and Two-Bit riffles. In other SOCs such as running upstream through Upper Galice, there could be other LOS conditions more restrictive to pvt-JBs than MTBs. Most often however, the better operational options and RIPs closer to the set-down thresholds available to the smaller pvt-JBs allows them to safely operate past the MTB RIPs. This largely negates the visual advantage offered by the greater eye-position height of MTB operators.

Pvt-JB operational speeds are also important factors in potential safety risks at SOCs. Small high performance pvt-JBs have speeds as fast and faster than MTBs, however, in general within SOCs they have been observed to operate in the same speed range as MTBs. For these craft the transit rates are assumed to be the same as for MTBs and speed-related PSR factors would not change. Small low performance pvt-JBs however, have been observed to operate at significantly lower speeds within SOCs. Lower operational speeds influence PSRs in both downstream and upstream operational directions. When operating downstream slow JB transits increase the JB run time to the ST and increase the probability that FC can float past the ST during the JB run. This reduces the PSR and PMO. When operating upstream, longer transit times to the ST increase the probability that FC can float into the SOC from above during the JB run. This increases the PSR and PMO. How these various characteristics translate into SOC/scenario specific PMOs and MOs can only be

determined with a thorough SOC Assessment and SR/C Model using pvt-JB operational characteristics.

From field observations and as a result of the detailed SOC Assessment work undertaken for MTBs, it is likely that for any given recreation use and management scenario, estimated MOs for pvt-JB would be substantially reduced from those calculated for MTB operations. This results primarily from reduced SOC/scenario ISRs for pvt-JBs because of increased maneuver capacity of these smaller craft once in the SOC. Inspection of the individual MO situations in each SOC/scenario indicates that the greatest PMO and ISR reductions would occur in those MO situations that are speed and space related. In downstream operations this includes JBs overtaking FC in through-run situations and for upstream operations, float-ins and float-bys in set-down areas. The PMOs and ISRs for pop-outs and LOS thresholds in close proximity to on-plane JBs would not be materially reduced by pvt-JBs. Therefore in general, pvt-JBs should have reduced PSRs, ISRs, and PMOs for specific SOC/scenarios and reduced MOs for specific recreational management scenarios. There is a greater range of operator experience and skill among pvt-JB operators than among MTB operators. This makes the "best" operating skill and "prudent" judgement factors problematical for pvt-JB uses and increases the possibility that Overt MOs would occur.

With respect to the SOC Hazard Severity Ratings (HSRs) discussed in Appendix H, for each safety risk situation, the use of pvt-JBs should generally result in reduced MO probability, reduced accident probabilities, and reduced accident severity. This results from increased craft maneuvering capabilities within the SOCs, shorter PSDs and SSDs, smaller craft footprint size, and increased channel areas available to FC. The magnitude of HRS reduction for pvt-JBs would be least in MO situations involving on-plane passes of pop-out areas and short range LOS thresholds.

For most SOC/scenarios, pvt-JB operators have nearly the same LOS thresholds as do MTB operators and, like MTBs, in most cases it is not possible for pvt-JB operators to see to the next safe operational stopping point. Exceptions to this rule are SOC/scenarios in which small set-down areas within SOCs are usable by pvt-JBs for setting-down and turning around to completely stop. The most notable SOCs with set-down areas that allow pvt-JBs to stop while MTBs cannot, include downstream operations at Hog Creek Islands and downstream operations at Hellgate Riffle. In all other SOC/scenarios, pvt-JB and MTB operators have similar LOS limitations from the RIPs to the STs and, therefore, by the same logic as above for MTB operations, the SOCs are not safe for pvt-JB use because operators must commit to entering an SOC without being able see through to a safe stopping location. Once in the SOC, however, because of greater maneuvering capabilities and shorter SSDs, etc., given the same operator skill level and prudent judgement, the pvt-JBs provide greater margins of safety to accommodate FC without incurring MOs and incurring accidents.

c) SOC Hazard Severity Rating; In the SOC Assessment and SR/C Model steps, safety risks for SOC/scenarios are calculated in terms of the probability of "inadvertent" incidents of mutual occupation (PMOs) and the estimated number of MOs that may occur under specific management scenarios when "Medium" sized MTBs are in use. PMOs and MOs relate only to the likelihood of the mutual occupation in potential safety risk areas; they neither address the likelihood that an accident will actually occur nor the probable severity of any actual accident. By inference the PMO and MO modeling products assign each MO situation with an unspecified but equal likelihood that a MO will or will not result in an accident and an equal but unspecified level of damage that may result from the accident.

In fact field review of SOCs show that in each SOC/scenario many possible MO elements may exist involving different MTB operational modes, varying specific locations of MTB/FC encounters, varying channel, bank and hydraulic circumstances, and MTB operational modification options. These and other site specific circumstances embody each SOC/scenario MO element with varying probabilities that the MO situation will lead to an accident as defined in this BS/C Study, and varying accident severity potential. Some potential safety risk situations may occur relatively often but may amount to nothing more than casual co-occupation of a section of the SOC while other situations, because of precise timing/location requirements of the craft involved, may be relatively rare but have the potential for on-plane MTBs to physically overrun FC in tight channel conditions and with very short operator reaction time options. Since the measure of safety risks in the SR/C Model is based only on the relative probability of a MO occurring there is no accounting in the results for the potential severity of the MO situation. The HSR

evaluation has been included in this BS/C Study to balance the MO incident probability results of the SR/C Model with accident probability and accident severity factors. Details of the HRS process and the HSRs for each separate MO element for each SOC/scenario are presented in Appendix H.

The MO probability, accident probability and possible accident severity assignments to each MO element of each SOC/scenario were based on the professional judgement of WRC field staff. The categories, functional definitions, and the category assignments were developed based on the observations during the field season, input received during the FG process and the comments made by MTB and pvt-JB operators during the study period. Neither the FG members nor the staff of the cosponsoring agencies were involved in the development of the HSR and did not review nor approve or reject the conceptual approach nor the results.

The HSR was intended as only a relative guide for resource managers and river users when considering issues of potential safety risk. The HSRs were not used in any of the quantitative modeling of safety risks in the BS/C Study. For each of the MO element situations the MO probabilities, accident probabilities, and the possible accident severity rating are listed so that the relative accident and accident severity potential can be judged independently. HSR information should be considered along with the SOC PMOs and MOs when addressing safety risks at site specific locations.

3) MTB Itinerary Schedule Issues:

Within the context of the ISRs of the various SOC/scenarios (see preceding section) the major element in safety risk exposure in the Hellgate Study Reach is the level of FC activity expected at the SOCs when MTBs arrive. FC use levels at particular SOCs result from the general level of FC uses in the study reach on any particular day, the typical spatial and temporal distribution of the FC users throughout the study reach in a recreation day, and the MTB trip itinerary schedule.

The BLM user information showed that the number of MTB craft that are part of MTB trips and the number of MTB passengers can vary dramatically on a daily and monthly basis from May 1 through September 30 as well as during the MRS (Walker and Austermuehle 1994). While in the MRS the MTB craft trip numbers and passenger numbers both vary on a daily and monthly basis, the number of MTB trips during the 1992 MRS were observed to diverge little from the daily trip schedule. From these observations it was inferred that during the MRS, variable demand is generally accommodated by reduced numbers of individual MTB craft on MTB trips not by a reduction in the number of daily scheduled MTB trips. Therefore, the number of lead MTBs on the Hellgate Study Reach vary little from day to day through the MRS and the MTB trip itinerary schedules presented in Figure 31 adequately represents the daily pattern of MTB lead craft activities.

As a result, during the MRS, daily MTB activity in the Hellgate Study Reach is fairly constant and MTBs are on the water at least somewhere throughout most of the recreation day. MTB use is particularly heavy in the Scenic Section. At any given point on the 19.6 mile long Scenic Section there can be up to 38 individual MTB craft passes in 5 or 6 MTB trips. This is 10 to 12 lead MTB craft passes a day through each SOC. Daily MTB activity in this section can range over about 12 hours (0845-2030) near Grants Pass and over about 10 hours (0930-1900) at Hog Creek Ramp. On the 13.6 mile long Whitewater Section, MTB activities can include up to 12 MTB craft passes daily on 2 MTB trips; 4 lead MTB craft passes through each SOC. Daily MTB activity in this section can range over about 9 hours (0945-1845) at the Indian Mary Ramp and over about 7 hours (1015-1715) at the Grave Creek Ramp.

During a typical day in the MRS the FC Use Distribution Model indicates that FC activity concentrations are greatest in the Whitewater Section and that portion of the Scenic Section below Hog Creek Ramp from about 1030 hrs. to about 1930 hrs. (See Figures 5 and 6).

To address the issue of the influence of MTB use pattern and MTB trip itinerary scheduling on safety risk exposure, the SR/C Model was run for 1992 conditions under both low and high flows. Based on the standard 101 day long MRS, the safety risk exposures for the two flow level conditions were based on several assumptions; 1) all scheduled MTB trips were undertaken in accordance with the daily schedule shown in Figure 31; 2) all MTB trips ran as single convoys and had only one lead craft; 3) no additional "special" MTB trips occurred; 4) physical characteristics of SOC were those observed in 1992; and, 5) FC user patterns were those observed in 1992 including seasonal use levels, weekend-day and weekday use level splits, and FC user distribution, etc. The SR/C Model results are presented in

Table 5. The basic result of this model run is that over the MRS, 316 MO incidents are predicted under low flow conditions and 244 are predicted under high flow conditions.

Further inspection of Table 5A shows that under low flow conditions about 145 MOs (46%) are expected at the SOCs in the Scenic Section and 171 MOs (54%) in the Whitewater Section during the MRS. These results indicate under low flow conditions MRS MOs are divided about evenly between the two study sections even though only 2 daily MTB trips run the SOCs of the Whitewater Section versus the 5 or 6 MTB trips through the SOCs of the Scenic Section. Therefore for low flows even though the SOCs in the Scenic Section have a substantially higher average ISR than do the SOCs in the Whitewater Section (.279 v. .131; see Table 4A), the greater number of SOCs and the higher FC use levels in the Whitewater Section result in roughly equal estimated total MRS MOs. When considering the total MRS and comparing MOs on the basis of MTB trip itinerary schedules under low flow conditions (Table 5A), the average MTB trip through the Whitewater Section has a 224% greater level of safety risk exposure than does the average MTB trip through the Scenic Section (171/2=85.5 v. 145/5.5=26.4). These results show that while at low flows the study reach sections have roughly the same total safety risk exposure over the course of the MRS, each MTB trip through the Whitewater Section is about 2.25 times as likely to encounter incidents of safety risk exposure as is each MTB trip through the Scenic Section.

Under high flow conditions the predicted total MRS MOs for conditions observed in 1992 is 244, a 23% reduction (316 to 244) from the low flow conditions and the study reach split shifts to 80 (33%) and 164 (67%) for the Scenic and Whitewater sections respectively. The Whitewater Section MRS MOs are considerably greater than those of the Scenic Section even though the average high flow SOC ISR is higher than the Whitewater Section SOCs (.166 v. .116; see Table 4A). The major influence in these high flow condition MRS MO changes is a 45% reduction in Scenic Section MOs (145 to 80) while MOs in the Whitewater Section only decline by 4% (171 to 164). Under these higher flow conditions the 2 MTB trips together through the Whitewater Section account for 2 times as much safety risk exposure as do the 5 or 6 daily MTB trips through the Scenic Section combined (164 v. 80). The conclusion of these model runs is that at higher flows, the flow condition typical during normal MRS years, the total MRS safety risk exposure in the Whitewater Section is 100% greater (164 MOs v. 80 MOs) than in the Scenic Section. When considering the total MRS and comparing MOs on the basis of MTB trip itinerary schedules, each of the 2 MTB trips through the Whitewater Section have a 466% greater level of safety risk exposure than do each of the 5 or 6 MTB trips through the Scenic Section (164/2=82 v. 80/5.5=14.5). These results show that under high flow conditions the Whitewater Section is twice as likely to have MOs during the MRS and that each MTB trip through the Whitewater Section is about 5 times as likely to encounter MOs as each MTB trip through the Scenic Section.

The model results generally support the input from the FG members and the results of WRC field observations that the Whitewater Section is the portion of the Hellgate Study Reach with the greatest degree of potential MTB/FC safety risk. In conjunction with the preceding discussion of SOC ISRs, this model run also shows that the greater safety risk exposure is not due to the physical characteristics of the SOCs but the number of SOCs (5 v. 9) and the number of FC involved with MTBs at SOCs. The results also indicate that with increased recreational FC uses in the Scenic Section, such as increased canoe and general FC uses or increased driftboating during the angling season, MOs could be expected to increase sharply.

Safety risk exposure also varies greatly with specific MTB trip itinerary schedules. As can be seen on Table 5B, at either flow level the 2 individual Whitewater trip itinerary schedules each have greater MRS MOs than do the 4 Scenic Section MTB trip itinerary schedules combined. Under low flow conditions the Whitewater trip itinerary schedules have 70% of the total MRS MOs (220 v. 97) and under high flow conditions 79% of the total; MRS MOs (192 v. 52). On a MTB trip itinerary schedule basis, the 4 Scenic Section itinerary schedules have an average MRS MOs of 24 (97/4) and 13 (52/4) for low and high flows respectively. The 2 Whitewater Section itinerary schedules have average MRS MOs of 110 (220/2) and 96 (192/2) for the low flow and high flow conditions. This indicates that over their entire route, Whitewater MTB itinerary schedule trips are from 4 (110 v. 24) to 7 (96 v. 13) times more likely to encounter SOC MOs than are the average Scenic Section MTB itinerary schedule trips.

Under low flow conditions the MRS MOs of either the AM or PM Whitewater trip are about equal to the total for the Scenic Section trips and at high flows each Whitewater trip has greater MRS MOs than the combined Scenic Section trips. The Whitewater trip itinerary schedules are clearly the most significant contributor to the MRS MOs in the study reach. Of secondary importance to safety risk exposure are the PM Scenic and Dinner trips with 34 and 21 MRS MOs respectively. The MTB trip itineraries with the least safety

Table 5

SEASONAL SAFETY RISK INDEX SUMMARY
Hellgate Study Reach

A: Summary By SOCs and Study Reach Sections - All MRS MTB Trips

SOCs	Low Flow Conditions				High Flow Conditions			
	Weekday MRS MOs	Weekend MRS MOs	Holiday MRS MOs	Total MRS MOs	Weekday MRS MOs	Weekend MRS MOs	Holiday MRS MOs	Total MRS MOs
Scenic Section SOCs								
Middleton's Riffle	5.920	4.990	0.406	11.316	2.672	2.370	0.184	5.227
Applegate	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Whitehorse Riffle	12.234	10.523	0.876	23.633	7.918	7.411	0.584	15.914
Brushy Chutes	18.256	15.443	1.270	34.969	4.913	4.585	0.354	9.852
Two Bit Riffle	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Hog Creek Island	17.956	16.566	1.038	35.560	15.378	13.918	0.886	30.181
Hellgate Riffle	22.406	16.034	1.299	39.739	10.612	7.687	0.624	18.923
Subtotal	76.773	63.555	4.890	145.218	41.493	35.972	2.632	80.097
Whitewater Section SOCs								
Dunn Riffle	5.588	3.900	0.390	9.878	5.588	3.900	0.390	9.878
Ennis Riffle	0.704	0.483	0.048	1.235	0.704	0.483	0.048	1.235
Upper Galice Chute	18.248	8.609	0.861	27.718	18.248	8.609	0.861	27.718
Lower Galice Chute	14.621	8.557	0.856	24.034	11.911	7.033	0.703	19.648
Rocky Riffle	7.961	4.513	0.451	12.925	6.315	3.620	0.362	10.297
Mark's Island	14.612	8.731	0.873	24.215	14.397	8.731	0.873	24.215
Bailey Riffle	25.227	14.330	1.433	40.990	25.241	14.046	1.405	40.692
Argo Riffle	14.397	8.259	0.826	23.482	14.397	8.259	0.826	23.482
Wooldridge Riffle	3.952	2.466	0.247	6.665	3.925	2.451	0.245	6.621
Subtotal	105.309	59.848	5.985	171.142	100.939	57.133	5.713	163.785
TOTAL	182.082	123.403	10.874	316.359	141.432	93.104	8.346	243.882

B: Summary By MTB Trip Itinerary Schedule

MTB Trip Itinerary Schedule (number of MRS trips)	Low Flow Conditions					High Flow Conditions				
	Weekday MRS MOs	Weekend MRS MOs	Holiday MRS MOs	Total MRS MOs	Average MOs per MTB Trip	Weekday MRS MOs	Weekend MRS MOs	Holiday MRS MOs	Total MRS MOs	Average MOs per MTB Trip
AM Scenic (101)	12.276	7.761	0.776	20.812	.206	6.455	4.173	0.417	11.045	.109
PM Scenic (101)	22.661	14.924	1.492	39.077	.387	13.232	8.916	0.892	23.039	.228
Dinner (101)	12.877	8.350	0.835	22.062	.218	4.958	3.207	0.321	8.485	.084
Brunch (26)	0.000	14.660	0.000	14.660	.489	0.000	9.648	0.000	9.648	.322
Subtotal (329)	47.814	45.695	3.103	96.612	.294	24.644	25.943	1.630	52.217	.159
AM Whitewater (101)	73.903	42.311	4.231	120.445	1.193	67.284	38.213	3.821	109.319	1.082
PM Whitewater(101)	60.365	35.397	3.540	99.302	.983	50.503	28.948	2.895	82.346	.815
Subtotal (202)	134.268	77.709	7.771	219.747	1.088	117.788	67.161	6.716	191.665	.949
TOTAL (531)	182.082	123.403	10.874	316.359	.596	142.432	93.104	8.346	243.882	.442

Note: MRS MOs for 1992 conditions using final SOC safety risk parameters.

risk exposures are the AM Scenic and the Brunch trips with 18 and 13 MRS MOs respectively. On the basis of MTB trip itinerary schedules the riskiest trip is the AM Whitewater with 120 and 109 MRS MOs for the low flow and high flow conditions. The least risky daily MTB trip itinerary schedule is the Dinner trip with 22 and 8 MRS MOs for low flow and high flow conditions. It should be remembered that these model results assume that the multiple MTB craft on each trip operate as one tight convoy; split convoys should be modeled as having two lead craft. In the case of the Dinner trips, they are mostly run as two convoys so the MRS MO results should be doubled to 44 and 16 for the two flow conditions to more accurately reflect potential safety risks.

The Whitewater trips are also the most risky when safety risk exposure is considered on the basis of the number of individual daily MTB trips on the various MTB trip itinerary schedules over the MRS. The per trip average MOs for the Whitewater trips vary from 0.8 to 1.2 depending on schedule and flow range. For the Scenic Section trips the average per trip MOs vary between about 0.1 and 0.5. Therefore on the basis of individual trips, throughout the entire trip itinerary, Whitewater trips can have from 1.5 to 10 times the level of safety risk exposure as an average Scenic Section MTB trip. On a trip by trip basis the riskiest MTB trips in the Scenic Section are the Brunch and PM Scenic trips with 0.5 and 0.3, and 0.4 and 0.2 MOs per trip for low flow and high flow conditions. The safest MTB trips are the AM Scenic and the Dinner trips (for qualifications on Dinner trip MRS MO results, see above).

The general MTB itinerary schedule conclusions are that the Whitewater MTB trips are the riskiest in the study reach. About half or more of the study reach MRS MOs occur in the Whitewater Section and about 70 to 80% of the total MRS MOs occur on Whitewater trips over their entire itineraries.

Any change in MTB trip itinerary schedules could either increase or decrease estimated MOs. Given the FC daily spatial and temporal use pattern in the study reach with a concentration on mid-day and afternoon activities and the present available MTB craft in the fleet, little flexibility is left in the recreation day to reschedule trip itineraries so that encounters with FC at SOCs can be reduced. With respect to MTB itinerary schedules, safety risk exposure can be reduced most expeditiously by reducing the number of MTB trips and the number of lead craft. This can result from fewer daily scheduled MTB trips, reduced number of days of MTB operations through the MRS, or running smaller trips that do not break up into multiple convoys. Using the SR/C Model results for 1992 conditions (Table 5) three possible avenues are explored below for reducing the number of lead MTBs by reducing trips numbers.

It was generally perceived that most of the potential safety risk and conflict between JBs and FC occur on some particular weekends and holidays when there is substantial FC use activity (Appendix K; Focus Group Meeting Notes, 70, 116, 148-9. This is particularly true in the Whitewater Section which has the largest proportion of FC users. Visitor information for 1991 (Austermuehle 1992) indicates that the weekend-day and holiday daily FC use levels are about 53% greater than weekdays. Peak weekend days and holidays in the MRS could have even greater use levels. If MTB trips are not run in the Whitewater Section on those 10 or so very busy weekend days and holidays, reductions in safety risks and conflicts would occur. If these 10 MTB closure days are assumed to occur on 2 holidays and 8 weekend days, the MTB activity days in the MRS would be 68 weekdays, 22 weekend days, and 1 holiday. These changes in MTB MRS activity would reduce the MRS MOs by 12% for both flows (low flows, 316 v. 279, and high flows, 244 v. 215). If in compensation, the same number of additional MTB trips were allowed on the remaining "open MTB days" as were foreclosed on "closed MTB days", initial SR/C Model results using the initial SOC safety risk parameters (Appendix L; Draft Safety Recommendation Elements, Safety Risk and Conflict Implications, Hellgate Study Reach) indicate MRS MOs could increase by <1-2% over present baseline safety risk exposures. This increase results because the only times available for additional trips in the daily MTB schedule are mid-day, high FC use periods. Problems with a management approach that involves "peak use" MTB closure days includes the scheduling of MTB closure days early enough in the season to provide for adequate MTB business operations on the one hand (trip booking and passenger rescheduling problems), and the unpredictability of "peak use day" occasions on the other.

General on-river users, particularly fly-anglers, have expressed the opinion that the all-day, every-day MTB itineraries, the relatively high number of daily MTB passes, and the early morning and evening concentrations of MTBs (See Figure 31) create general and pervasive on-river conflicts. A regularly scheduled all-day MTB closure each week could provide non-conflict recreation days for the use of local recreationists. If 2 weekdays each week were regularly scheduled as MTB closure days there would be about 26 closed weekdays in the MRS and would reduce the number of weekdays in the MRS from 68 to 42. For the 1992 conditions this reduced level of MTB activities would result in a 38% reduction in the weekday MRS MOs (182 to 113 for low flows, and 141 to 87 for high flows). These

reductions would reduce overall study reach MRS MOs by 22% for both flow levels (low flows, 316 to 247, and high flows, 244 to 190). If in compensation, the same number of additional MTB trips were allowed on "open MTB weekdays" as were foreclosed on "closed MTB weekdays", initial SR/C Model results using the initial SOC safety risk parameters (Appendix L) indicate MRS MOs could increase by about 10% over present baseline safety risk exposure conditions. This increase results because the only times available for additional trips in the daily MTB schedule are mid-day, high FC use periods.

Another possible MTB closure schedule is regularly scheduled closure days on Sundays and Mondays. Based on the makeup of the MRS this closure schedule would include on average about 10 weekdays, 15 weekend days, and 3 holidays that fall on Mondays; 14.7, 50, and 100% reduction in the three day-types respectively. This level of reduced MTB MRS activity would reduce MRS MOs by 31% for both flows (low flows, 316 to 217, and high flows, 244 to 167).

Both of these regular-schedule closure options would allow the closure days to be set and known early in the year and could be accommodated by the MTB owner/operator in the scheduling and booking of trips. These closures would also be easily enforced by management agencies. If use levels warrant, weekly closures could be extended to additional days and could include pvt-JBs as well. In addition to reduced safety risk exposure, these regularly scheduled closures could also reduce recreation resource conflicts with a wide range of users. MTB closure days without compensatory trips on open days would result in reduced MTB passenger capacity and reduced study reach visitation by MTB passengers.

During the fall Chinook runs of August and September, angling by driftboat and by bed and bank users occurs throughout the Hellgate Study Reach but is concentrated in the Scenic Section; particularly the 13 miles between Eiseman's Stillwater and the Hog Creek Ramp. Angling use is concentrated in this area because of the abundance of low gradient riffles leading into large pools and runs, and also the prevalence of bedrock ledges that provide the fish with good holding water and cover. The Scenic Section above Hog Creek Ramp is also generally composed of riffles, runs, and pools which are easily navigated by driftboaters with low or average boating skill. The Whitewater Section generally contains rapids that are complex with relatively high water velocities and hydraulic intensity which require more driftboat navigational expertise. As a result the Scenic Section probably has about 90% of the study reach angling uses (Austermuehle 1992).

A substantial portion of the BS/C issues generated by MTB activities during the September fishing season could be resolved by extending the morning time limit for passing the mouth of the Applegate River from 0830 hrs. to 1200 hrs. Most serious driftboat anglers could get in a least a 6 hr-day of angling before MTB traffic occurred and BS/C issues developed. Wading fly-anglers would also have a considerable portion of an activity-day available without resource value conflicts and without any BS/C concerns.

Driftboats, when used for angling, have very different use patterns in SOCs than do driftboats and FC when used for recreational floating. Driftboats often spend from 10 minutes to 2 hours or more at the head or tailwater of riffles where angling activities are undertaken. These facets would lead to changes in SOC occupation and float times, changes in the SOC Assessment results, and changes in the 15-minute float segmentation in the FC Use Distribution Model. The FC Use Distribution Model was not altered to accommodate driftboat angling activities, therefore additional modifications are necessary before the SR/C Model can be used to quantitatively address the BS/C concerns associated with this activity.

4) Use Activity Levels and BS/C Issues:

It was generally recognized by experienced users of the study reach that for a given MTB use pattern, BS/C issues and concerns are related to FC use levels (Appendix K; FG Meeting Notes, 123-4). As the numbers of FC users on the river increase so do safety issues in SOCs. This is also true with respect to general on-river users; as use levels of all activity types increase the frequency of encounters with potentially conflicting users increase. As encounters increase the potential for adverse, conflicting or safety risk inducing incidents increase.

With respect to the present MTB activity regime, continually increasing FC use levels will lead to progressively increasing safety risk-related conflicts and user accommodation of others, increasing resource conflicts, and increasing Overt MOs. Eventually these conditions will represent levels of crowding, loss of resource values, user displacement, and potential safety risks that are unacceptable to individuals and user groups. These conflict and safety risk problems are likely to be experienced by all user

activity types but in varying degrees and varying significance to the recreational environment. Dissatisfaction may be realized by user dislocation. User dislocation can be expressed by changing use patterns that may include time of day of uses, location of activity within the study reach, and modified activity patterns based on day-type, but could also include the use of other regional resources or disengagement from the activity. Each individual and user activity group have varying tolerances for conflicts and varying thresholds at which dislocation may occur. Input from the FG process indicated that some users are dislocated under present use levels (fly-anglers and pvt-JB operators) while other may have tolerances for considerably greater use levels (MTB operators and commercial raft owner/operators).

While it is generally accepted that crowding, conflicts, and safety risks will increase with increasing use levels in all recreational activity types, the SOC Assessment and SR/C Model indicated a more complex and intricate relationship between the number of FC present and the level of BS/C issues. There are several dimensions to this relationship: 1) the number of FC encountered at each of the SOCs and influence this has on MTB operational decisions that lead to, 1a) potential safety risk, or 1b) safety risk-related conflicts; and, 2) the accumulation of BS/C incidents on the whole study reach over an entire MRS that may result from varying use levels.

a) Individual SOC Safety Risks; The Safety Risk/Conflict (SR/C) Curves for each SOC/scenario represent the relationship of calculated PMOs over a range of hypothetical FC use levels. For each increment of potential FC use level the SOC Assessment procedures were used to calculate the probabilities that the rapid is occupied by FC (PROs) and the probabilities that all FC in the SOC are unseen (PNSs). The PNSs determine the MTB run operational scenario employed using the assumed MTB operational rules and the fault-tree assessment method (See Figure 27). If and when a MTB is stopped to wait at a RIP it is assumed to wait until the operator determines, to the extent that observable information allows, that the SOC is clear of FC. The PMO calculated for each FC use level increment is a composite of the PMOs associated with the two MTB operational scenarios; running directly into the SOC, and stopping and run re-initiation. The probabilities for the MTB operational scenarios (as expressed by the PI curves), and total safety risk exposure (both direct run and stop and run re-initiation scenarios as expressed by PMO curves), are best interpreted as probabilities associated with innumerable MTB runs at each FC use level rather than a single MTB run at different FC use levels.

Four main factors drive safety risk responses to varying FC use levels. These include; 1) SOC length; 2) PNS; 3)MTB operational direction; and, 4) flow related channel/hydraulic conditions.

i) SOC Length; SOC length, in terms of FC float time, determines the "size" of SOCs relative to 15-minute float segments and, through the SOC Assessment process, determines the probability that FC will be in the SOC at any given moment of a 15-minute interval. Larger SOCs have higher PROs at any given FC use levels than do shorter SOCs. Depending on whether the FC are seen or unseen, greater PROs lead to greater safety risks and/or wait incidents at SOCs.

SOC length is set by the average FC float time over the full length of the SOC from the RIP to the ST. The RIPs and STs are set by channel depth and by the assumed MTB PSDs and SSDs. As a result, SOC lengths can vary with flow level, operational direction, the MTBs in use, and with changes in channel geometry and depth.

Middleton's Riffle is a relatively short SOC, ranging from about 620 to 1000 ft. long depending of flow condition and operational direction (See Plates 3 and 4). The safety risk and conflict parameters for this SOC for low flow, downstream and upstream MTB operating direction SOC/scenarios are shown on Figure 30. The upstream operating direction SOC length is greater due to SOC geometry and an additional hazard area above the ST that accommodates FC floating into the SOC during the MTB run time (See Plates 2 and 4). The shorter downstream SOC has a PRO of .50 at about 17 FC and reaches 1.0 at about 55 FC while the longer upstream SOC PRO is .50 at about 12 FC and 1.0 at about 35 FC. In the longer SOCs fewer FC in a 15-minute interval result in higher SOC PROs.

Upper Galice Chute is about 3500 ft. long regardless of flow condition and operational direction (See Plates 38 and 46), and is among the longest in the Hellgate Study Reach. This SOC shows very different PRO/FC use level relationships. For the Upper Galice SOC/scenarios on Figure 47, PROs of .50 and 1.0 are reached at 1 and 5 FC for both downstream and upstream operational directions. PROs are much

higher for any given FC use level for Upper Galice Chute because it comprises a very large proportion of a 15-minute float segment (about 50%). There is little difference in PROs for the two operational directions because the added increment of upstream SOC length that accounts for in-floating FC is only a small percentage of the overall SOC length (See Plate 47 and 48).

Most SOCs have lengths intermediate between Middleton's and Upper Galice and should have PRO/FC use level relationships more similar to those shown by Brushy Chutes (Figures 45 and 46). In general SOCs are longer under upstream MTB operations and therefore PROs are generally greater for those SOC/scenarios. The difference in PROs based solely on MTB operational directions is a function of the percentage change in length.

Some SOCs can be longer in downstream directions due to channel and LOS geometry. The PRO curve in the Brushy Chutes low flow example in Figure 45 shows that PROs are generally lower for upstream operations at any given FC use level. This indicates that the particular conditions of this SOC makes the SOC length greater for the downstream operational direction. In the case of Brushy Chutes there is a set-down area in the middle of the riffle that is usable for stopping for upstream operating MTBs only (Plate 13 and 17).

Higher PROs at any given FC use level will result in either increased safety risks or conflicts. All other factors being equal higher PROs result from longer SOC lengths.

ii) PNS; The probability that all of the FC that may be in a SOC are unseen is a function of the proportional size of the unseen area of the SOC from the RIP and the changing FC overlap as FC use levels increase. If the visible portion of the SOC from the RIP is very small it is more likely that a greater number of FC could be in the SOC and unobserved by MTB operators and MTB runs could be initiated at higher PROs. Conversely if the visible portion is very large it is more likely that at least 1 of the FC that are occupying the SOC will be visible from the RIP and MTB runs will not be initiated.

These relationships are shown by the Upper Galice Chute and Ennis Riffle SR/C Curves. For Upper Galice Chute, for the upstream operation scenario, the seen portion of the SOC is about 22.4% of the total SOC length (See Plate 46). For this SOC/scenario, Figure 47B shows that while the PRO reaches 1.0 at about 5 FC there is still a .20 probability that all of the occupying FC will be unseen at 13 FC and the probability of all occupying FC are unseen approaches zero only at about 40 FC. These probabilities are expressed by the PI curve. In this SOC/scenario, MTB runs are being initiated at FC use levels well above that at which the PRO is 1.0. By contrast, Ennis Riffle for upstream operations (See Plate 36) the visible portion from the RIP is about 98.2% of the total SOC length. Because most of the SOC is visible there is a close relationship between the PRO and the probabilities that the MTB run is initiated. As shown on Figure 48B the PRO at Ennis reaches 1.0 at about 15 FC but there is a .20 probability that all of the occupying FC will be unseen at about 12 FC and the probability that all occupying FC are unseen approaches zero at about 23 FC.

All other factors being equal as the proportion of SOCs that are visible from the RIPs increase, the probabilities that occupying FC are unseen decrease, safety risks decrease because FC are observed more readily, and conflicts increase because of greater wait incidents. SOCs with larger proportional visible areas tend to have lesser levels of safety risk at any given FC use level and greater wait incidents than do SOCs with proportionally small visible areas. Therefore with increasing FC use levels the SOCs with larger proportional visible areas tend to have PIs that decline very rapidly and, all other SOC safety risk factors being equal, PMOs should rise at a slower rate and peak at lower FC use levels.

This relationship is shown on most SOC/scenario SR/C Curves. Exceptions to this are the SR/C Curves for long SOCs such as Upper Galice Chutes (Figure 47). For this SOC/scenario, the PMO curve peaks at about .20, at about 5 FC per 15-minute interval, and stays flat throughout the rest of the FC use level range while MTB runs are being initiated through to about 43 FC per 15-minute interval. The initial implications are that MTB runs at FC use levels greater than 5 FC induce no more safety risk than at the 5 FC use level. This relationship is an artificial response of the SR/C Model that results from the modeling approach that MOs are estimated

based on the assumption that, only 1 FC is in the SOC. This single-FC occupation assumption was employed to simplify the modeling approach and to avoid infinite multi-FC combinations. This assumption results in generally lower estimates of MO encounters but, the increased safety risks associated with multi-FC is partially accommodated by the safe craft separation parameters which are based on the need for MTBs to safely accommodate multi-FC in each situations. For shorter and simpler SOCs this assumption, while underestimating MOs, provides generally reliable relative PMO/FC use level relationships. However, in long SOCs, where the PROs reach 1.0 at very low FC use levels, this assumption seriously underestimates PMOs and MOs. If a more complex iterative SOC Assessment approach were employed to accommodate multifarious multi-FC situations, the PMO curve in Figure 47 could be expected to rise at a steep rate to relatively high levels at relatively low FC use levels.

iii) MTB Operational Directions; The basic difference in the operational rules and fault-tree risk assessments for downstream and upstream MTB SOC runs create very different safety risk/FC use level relationships. As explained in i) above, upstream SOCs tend to be slightly longer for upstream MTB runs because of an added length increment to account for in-floating FC at the top of SOCs. In addition to this difference is the much more significant factor of the view field/knowledge field parameters used by MTB operators when determining that a SOC is clear of FC and when a MTB SOC run can proceed.

As presented in the SOC Assessment chapter in the fault-tree risk assessment approach discussion, after stopping at a SOC to wait for observed FC, downstream MTB operators are expected to wait long enough for the last observed FC to float to the ST. After waiting that length of time it is assumed that only FC involved with time-independent pop-outs would be part of any safety risks associated with MTB run re-initiation. This assumes that the operator's knowledge field grows with time to the point that the operator can accurately predict that the observed FC are past the unseen ST. Operators of upstream running MTBs, once stopped at a SOC RIP to wait for observed FC, can never determine the FC use pattern above the LOS threshold. Under that condition the MTB operator waits only long enough for the seen portion of the SOC to clear of observed FC before re-initiating the run. These different wait and run re-initiation scenarios result in very different safety risk/FC use level relationships.

Figure 45 for Brushy Chute low flow conditions represents the typical influence that MTB SOC operational direction have on safety risk/FC use level relationships. Downstream operations for this SOC/scenario show an increase in safety risk (PMOs) between zero FC and about 3 FC. At that FC use level the increasing PRO results in a greater likelihood that at least one of the occupying FC will be seen by the MTB operator at the RIP and the operator will stop at the RIP to wait. This leads to reduced PMOs with increasing FC use levels until a FC use level is reached that provides no chance that all the occupying FC are unseen; in this case at about 25-30 FC. For upstream operations, MTB operators re-initiate SOC runs as soon as the view field is clear of FC. As FC use levels increase the probabilities that these view field will become clear of FC decline but, if the view fields do clear of FC and the MTB run is re-initiated, there is an increasing probability that FC will be encountered and safety risk exposures will occur. As a result, for upstream operations, PMOs increase steadily with increasing FC use levels until the probability that the seen portion of the SOC being clear of FC at any time during a 15-minute period declines to zero. At higher FC use levels when the probability of the seen portion of SOCs being clear of FC is at zero, no MTB run occurs and the PMOs for upstream operations are zero.

All other factors being equal, with increasing FC use levels, safety risks at SOCs for downstream running MTBs tend to peak at relatively low FC use levels and then decline as conflict relationships become more predominant. For upstream running MTBs, safety risks generally increase at a constant rate to relatively high PMOs levels, then drop abruptly to zero at saturation.

SOCs vary widely in the balance between downstream and upstream safety risks with increasing FC use levels. In general, with increasing FC uses downstream MTB operations at SOCs result in consistently low safety risk exposure or peaks in safety risk at very low FC use levels. The low safety risk exposure regime is induced by increasing MTB stops at these SOCs. For upstream MTB operations, increasing FC use levels induce consistently increasing safety risk exposure until physical saturation of the SOCs occur.

iv) Flow Magnitude; Safety risks and conflicts are sensitive to flow magnitude to the degree that the channel/hydraulic conditions of the SOCs are influenced differentially by low and high flows and to the degree that these conditions lead to modified MTB or FC operations and use patterns. The most significant flow related channel/hydraulic changes which result in changing BS/C concerns are related to changes in MTB drifting options during downstream operations and changes in set-down threshold locations. The first factor allows for increased MTB operational time, while the second, which modifies the LOS thresholds and RIP and ST locations, makes SOCs shorter and increases the proportional size of the seen portion of SOCs. Both of these factors are in effect at Brushy Chutes and are represented in Figures 45 and 46.

For downstream MTB operations at Brushy Chutes, Plates 13 and 15 show that under high flow conditions there is an operation option to set-down and drift to the ST should a FC be observed after the MTB passes the RIP. This option does not exist under low flow conditions. When that is a viable operational option the MTB run time is longer and the ST is shorter because the SSD is shorter. With this change to a drift option at high flows, with increasing FC use levels the safety risk exposures shift from one that peaks at a relatively high level (about .17) and drops to near zero at about 25 FC (Figure 45A) to one that is very low and flat throughout the FC use levels until physical saturation (at about 23 FC) (Figure 46A).

Flow conditions can also alter the location of set-down thresholds. Plates 17 and 18 show that for upstream operating MTBs at Brushy Chutes only a relatively minor change in set-down threshold location can result in very different safety risk exposures for the two flow conditions. Between the two flow levels the upstream set-down threshold shift downstream about 90 ft. which is enough to change various safety risk parameters. Figures 45B and 46B show that, with increasing FC use levels safety risks increase at a much slower rate under high flow conditions and peak at about .52 instead of about .76.

At many SOCs higher flows result in greater water depth, channel width, and often greater water velocity and turbulence; however, because of abrupt bottom slopes the location of most set-down thresholds changed very little between the two flow levels. This is particularly true for the Whitewater Section where the hydraulics of most SOCs are controlled by bedrock conditions and invert slopes are steep. When basic channel configurations are not modified by flow levels the safety risk/FC use level relationships do not change. Figures 47 and 48 for Ennis and Upper Galice show that while many physical attributes of the SOCs change with flow the important safety attributes such as set-down thresholds, LOS thresholds, and effective channel width, etc., do not change enough to modify safety risk exposures.

Many SOCs do have safety risk attributes that change between low and high flow conditions. This is particularly true in the Scenic Section where many of the SOCs are closer to true riffles and have gentle invert slopes which create set-down threshold locations that are often, but not always, sensitive to flow changes. Where SOCs are sensitive to flow levels, low flows generally induce longer SOCs, reduced MTB operational options, and poorer lines of sight. These changes lead to safety risk/FC use level relationships at low flows that have PMOs increasing at a greater rate with increasing FC use levels and reaching higher levels of risk exposure than at high flows.

b) Individual SOC Conflicts; As presented in detail in the SOC Assessment chapter, "conflicts" used in this BS/C Study are "safety risk-related conflicts" and are defined as those non-accident conflicts between user activity types that could, if frequent, eventually lead to boating safety risks and potential accidents. As used here conflicts are embodied by the accommodations required in any of the SOC/scenarios by any user activity group, to avoid Overt MOs in SOCs. Calculated MTB waits for each of the SOC/scenarios are used as a surrogate estimate of these conflicts as they may be incurred by any and all user activity types. Estimated conflicts are based on the probability for each SOC/scenario, that the lead MTB of an arriving MTB trip will have to stop to wait for FC and the duration of those waits. This part of the SOC Assessment and SR/C Model provides insights into the relationships between FC use levels and the physical capacity of the SOC/scenarios.

The SOC SR/C Curves (See Figures 30 and 45-48) present several important wait incident related information over a range of hypothetical FC use levels: 1) the probability that an arriving MTB trip will have to stop at the SOC and wait for FC ("PWait"); 2) the average duration of a wait incident should one occur for evenly spaced FC ("0% Clumped"); 3) the average duration of a wait incident should a wait

incident occur for totally clumped FC ("100% Clumped"); and, 4) the average wait duration for each and every lead MTB ("MTB Wait"). For a detailed discussion on the derivation of the conflict curves see the SOC Assessment chapter.

Three physical attributes of SOCs drive the various conflict relationships over the FC use level range; 1) the length of the SOC which drives the PRO for any given FC use level; 2) the relative size of the seen portion of the SOCs which drives the probability that any of the occupying FC are seen from the RIP; and, 3) the float times of the FC through the MTB operator's knowledge field which in part drives the duration of the MTB wait. The two major conflict parameters are 1) the probability that wait incidents will occur; and, 2) the probable duration of the waits.

i) Wait Incident Probability; The influence that SOC length and the relative size of the seen portions of SOCs have on the probabilities that the SOC is occupied and that all FC are unseen was explained in the discussion of safety risk above. With respect to conflicts, these factors control the likelihood that at least 1 FC will be observed at any given moment of MTB arrival and, therefore the probability that the MTB will stop at the SOC RIP to wait. With increasing FC use levels and the larger the seen portion of the SOC, the greater will be the likelihood that at least 1 FC will be observed. The "PWait" curves indicate the probability that the operator of an arriving MTB will observe FC in the SOC and will stop. SOCs with very long seen portions have "PWait" that reach maximum levels at very low FC use levels such as for downstream at Upper Galice (Figure 47A) in which the probability of a MTB wait increases very steeply and reaches 1.0 at about 9 FC. Conversely for upstream operations at Upper Galice the probability of a MTB wait incident increases at a moderate rate through about 10 FC then gradually flattens and reaches 1.0 at about 42 FC. Based on the observable length of this SOC for the different operational directions, with increasing FC use levels, downstream MTB runs are much more likely to result in wait incidents.

A review of the "PWait" curves on the SR/C Curves (Figures 30 and 45-48) indicates that in most cases arriving MTBs have a .8 or an 80% chance of stopping to wait for observed FC at around 10 FC per 15-minute interval. This is a very high rate of accommodation and conflict at relatively FC low use levels. The exceptions to this are downstream at Upper Galice and Ennis where .80 probabilities occur at a use level of about 4 FC per 15-minute interval.

ii) Probable Wait Duration; Probable wait duration ("MTB Wait" on the SR/C Curves) is determined by the probability that a wait incident will occur (see above) and several FC use patterns and SOC attributes. The important FC user pattern and SOC attributes include: 1) the configuration of FC groups; 2) the length of the FC float from the point at which it was first observed to the end of the SOC; and, 3) the average FC float speed.

For the purposes of conflict modeling it was assumed that all FC that are expected in a 15-minute interval and are expected to float through the SOC in a 15-minute period are in single group; defined as 100% clumped. In this BS/C Study a group is a string of FC distributed such that continuously at least 1 FC is in the SOC. This leaves one continuous portion of a 15-minute interval in which there are no FC. The remaining two variables that drive probable wait duration are the length of the FC float to the end of the SOC and FC float speed.

Once a MTB has been stopped to accommodate FC users, the MTB operational direction and the lengths of the seen and unseen portions of the SOCs determine the length of channel the FC must float before it is clear of the SOC. When operating downstream the MTB operator was assumed to wait long enough for a FC, at average speed, to float to the ST. As a long term average conditions, this was assumed to be from the mid-point of the seen portion of the SOC, through the unseen portion of the SOC to the ST. When operating upstream the MTB operator was assumed to wait only until the FC clears the seen portion of the SOC by floating past the RIP. On average this would be from the mid-point of the seen portion through one half of the seen portion. Because of these differing MTB operational scenarios (See fault-tree discussion, Chapter IV, C)) at any given SOC the FC float length is different for downstream and upstream operational directions.

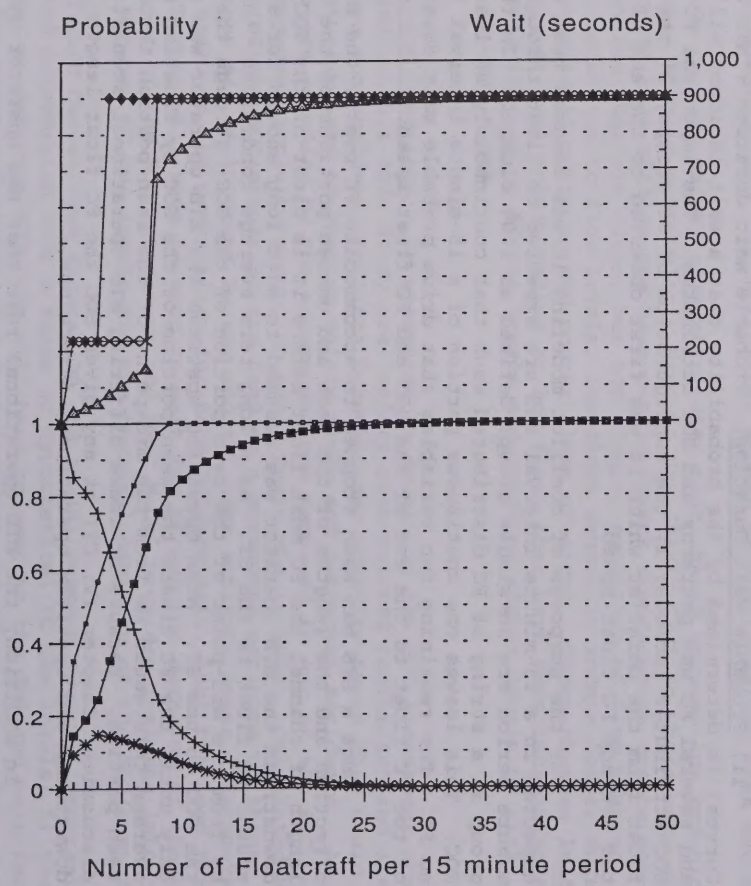
In addition, the MTB operational rule that the operator will not knowingly enter a SOC when it is occupied by FC requires that the gap between FC extend to the knowledge field of the MTB operator before re-initiating the run. For downstream

Figure 45

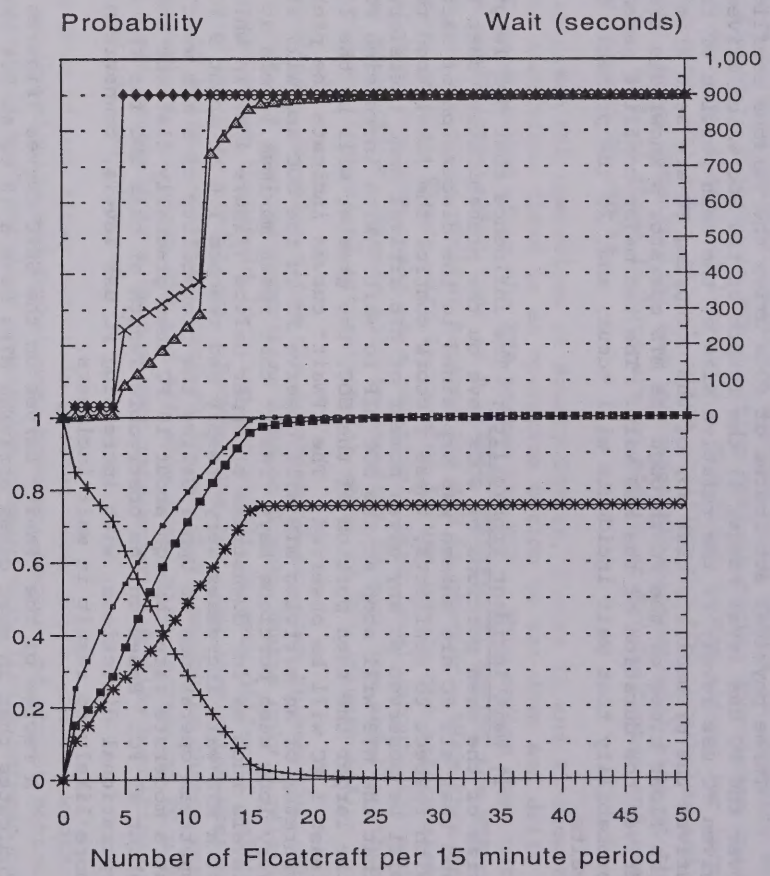
Safety Risk/Conflict Curves

Brushy Chutes
Low Flow

A. Downstream Operations



B. Upstream Operations



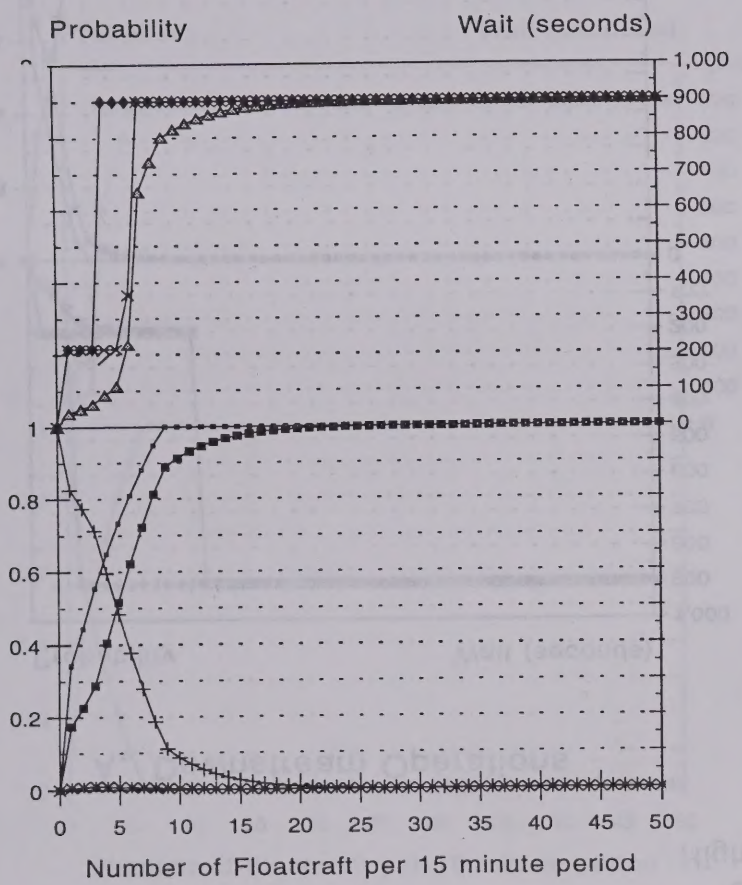
PRO PI PMO PWait Wait - 100% Clumped Wait - 0% Clumped MTB Wait

Figure 46

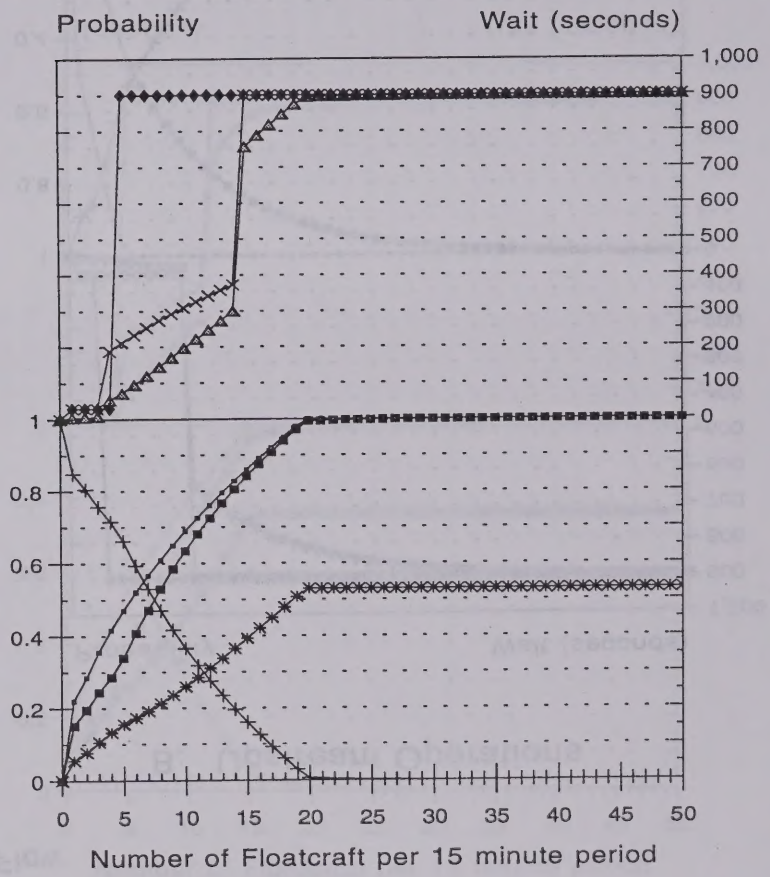
Safety Risk/Conflict Curves

Brushy Chutes
High Flow

A. Downstream Operations



B. Upstream Operations



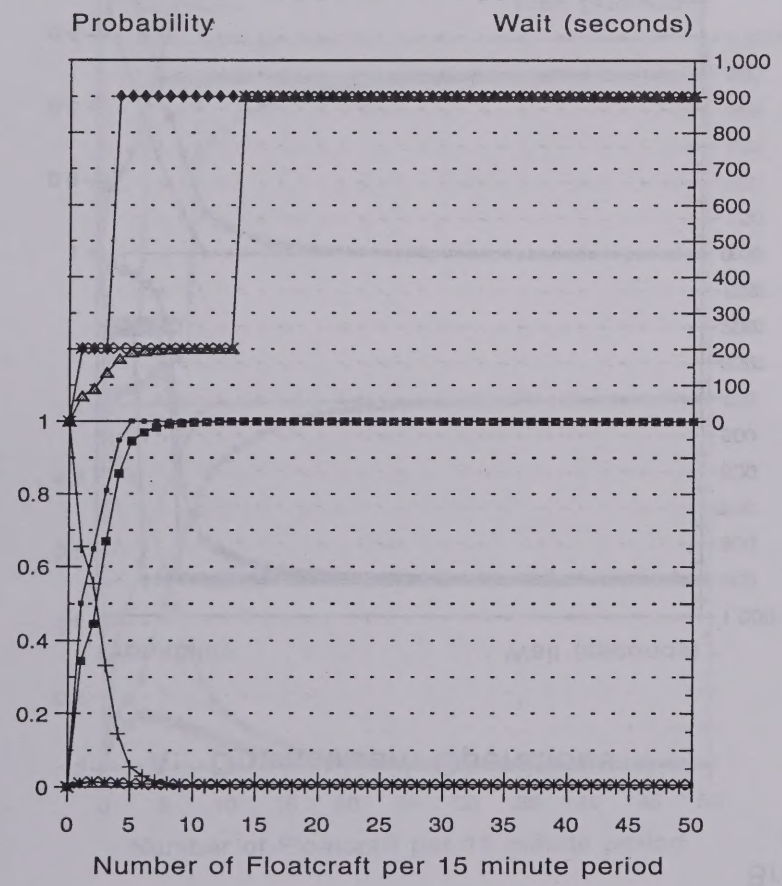
PRO PI PMO PWait Wait - 100% Clumped Wait - 0% Clumped MTB Wait

Figure 47

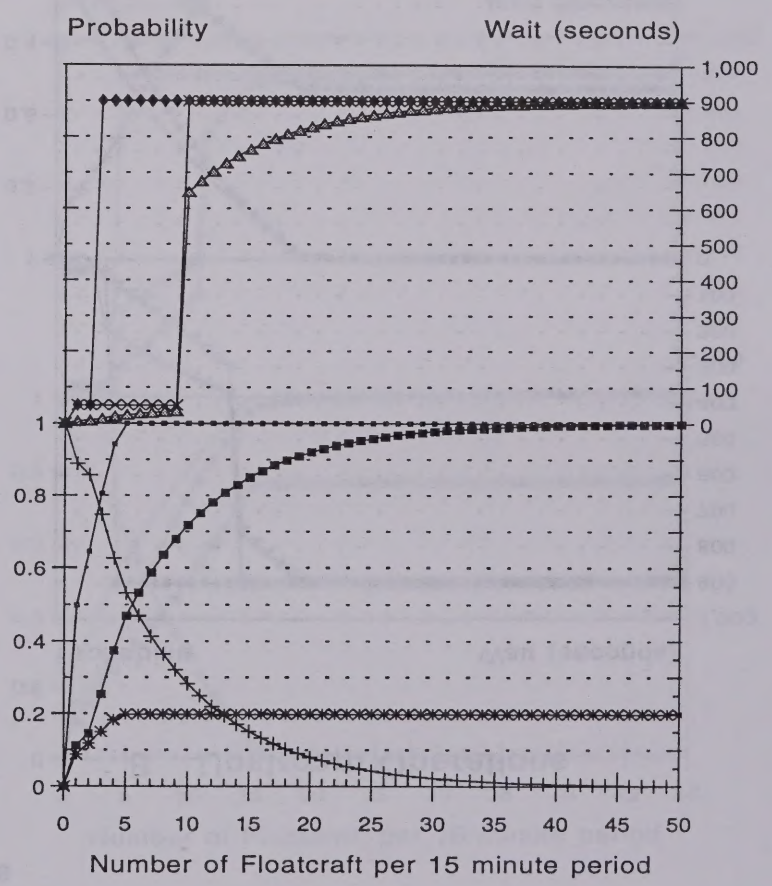
Safety Risk/Conflict Curves

Upper Galice
High and Low Flow

A. Downstream Operations



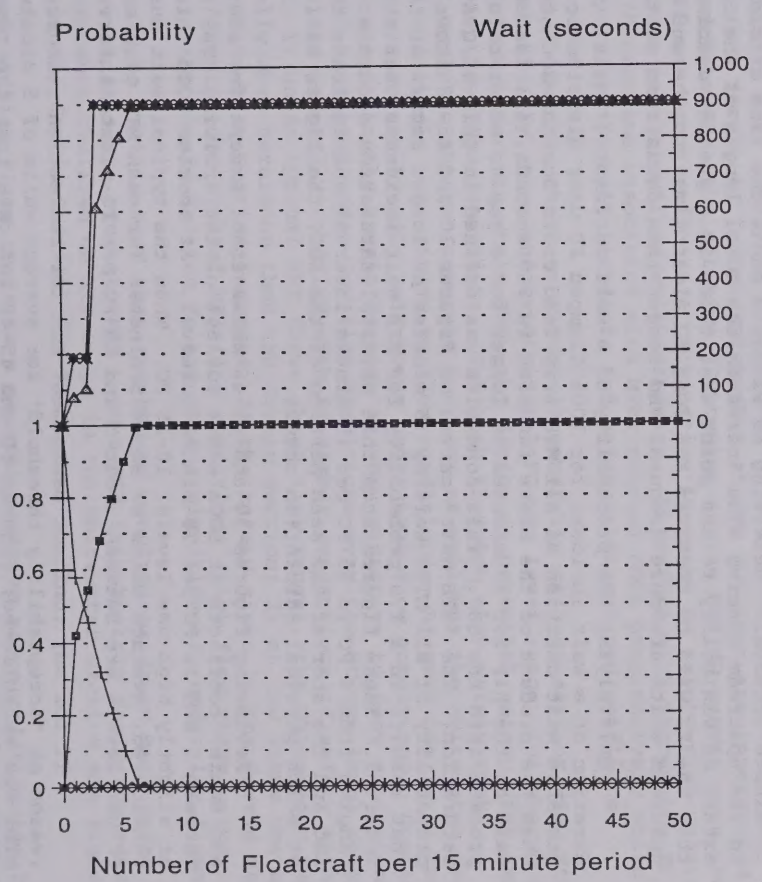
B. Upstream Operations



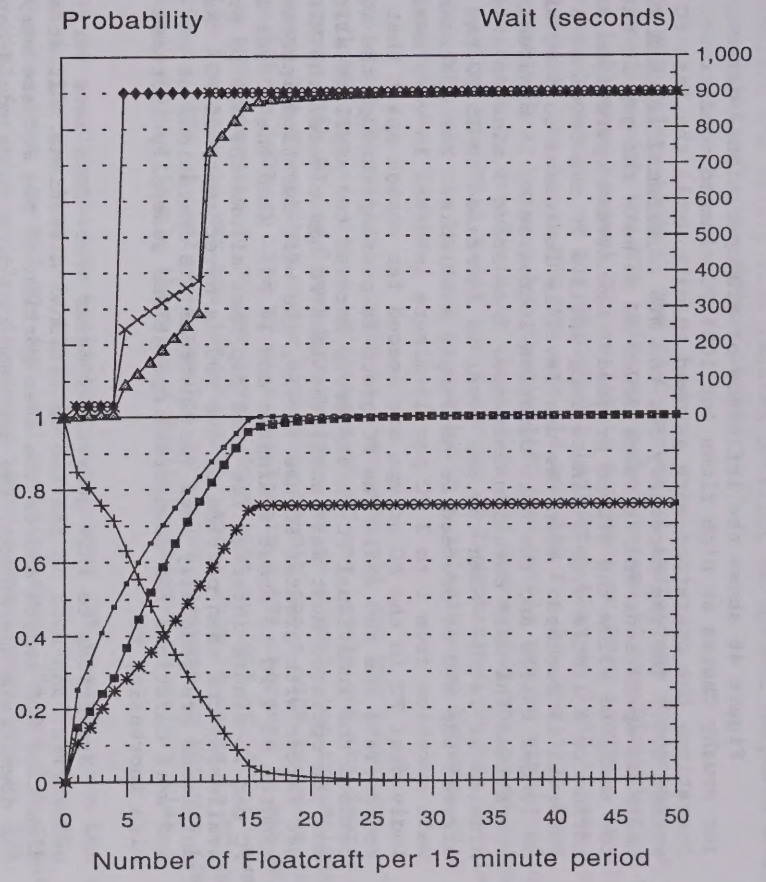
PRO PI PMO PWait Wait - 100% Clumped Wait - 0% Clumped MTB Wait

Figure 48
Safety Risk/Conflict Curves
Ennis
High and Low Flow

A. Downstream Operations



B. Upstream Operations



PRO PI PMO PWait Wait - 100% Clumped Wait - 0% Clumped MTB Wait

operations that would include the entire SOC and for upstream operations only the seen portion. As a result the time gap needed for a downstream MTB run is the average FC float time over the full SOC and for upstream operations the average FC float time through only the seen portion.

Figure 46 shows the influence of MTB operational directions on wait duration for Brushy Chutes at high flows for 100% FC clumped conditions. During downstream operations the operators were assumed to wait until the last FC floats through the entire SOC. The gap necessary for the MTB to proceed is then much longer than for upstream operations and it takes fewer FC to make the gap in the 15-minute interval too small to allow the MTB to proceed. Downstream operations are shown to have wait incidents a little over 3 minute long until a FC use level of 5 FC per 15-minute interval is reached. When the use level is increased to 6 FC the necessary time gap no longer exists and the wait duration increases to 15 minutes. For upstream operations the wait duration increases from about 3 minutes at 4 FC to over 6 minutes at 14 FC. When the use level is increased to 15 FC the time gap that allowed the MTB to proceed is no longer available. For upstream operations, the wait duration from 1 to 3 FC per 15-minute interval is very small because the individual FC in the FC groups are spaced far enough apart that the MTB operator can re-initiate the run while the FC group is passing through the SOC. At 4 FC the gaps between the individual FC in the group becomes too small to allow the MTB to proceed and the operator must wait until the last FC has cleared the RIP. As the FC groups get larger with greater FC use levels, the wait duration increases from about 2 minutes at 4 FC to about 6 minutes and 14 FC. When the FC use level increases to 15 FC per 15-minute interval the time gap that allows the MTB to proceed is no longer available; the seen portion of the SOC is never empty of FC. As a result wait durations are generally less for upstream MTB operations at any given FC use level and wait durations for downstream operations generally increase at a faster rate with increasing FC.

Exceptions to this generality occur where SOCs have very different lengths, geometries, and PNSs in the two operational directions. If at a SOC the upstream direction SOC length and/or the seen portion of the SOC are very much longer than for downstream operations, the upstream run directions could have greater wait durations. Middleton's is an example of this relationship. Figure 30 shows that waits at Middleton's are generally shorter for downstream operations at any given FC use level. The 100% Clumped curves for this SOC indicates that 5 minute waits exist at 25 and 17 FC per 15-minute intervals for downstream and upstream operational directions respectively and the acceptable MTB run gap is lost at 47 and 30 FC per 15-minute interval. Referring to Plates 2 and 4 the line of sight window available to the upstream running MTBs increases the total length of the SOC and the upstream extent of visibility to the point that there is a greater combination of likelihood that the FC will be observed and long FC float times to the end of the SOC such that upstream waits are more frequent and longer than downstream waits.

Multiplying the probability of a wait incident ("PWait") by the probable wait duration of a wait incident for 100% Clumped FC user distribution, results in the probable wait duration of all MTB trip lead craft for the SOC/scenario ("MTB Wait"). When the product of the above function is 900 seconds, all lead MTBs will have to wait at the RIP for 15 minutes or longer for a gap to occur before the trip can proceed into the SOC. This condition was defined in this BS/C Study as physical saturation. The "MTB Wait" curves on Figures 30 and 45-48 shows that 1.0 probability of all MTBs waiting 15 minutes or longer occurs at the same FC use level that results in a 1.0 probability for MTB wait incidents over the 15-minute interval. These figures show that physical saturation occurs at FC use levels ranging from 6 FC to 55 FC per 15-minute interval and indicate that the shorter the SOC and the shorter the seen portion of the SOC, the higher will be the FC use level at which physical saturation occurs.

Reviewing Figures 30 and 45-48 shows that, except for short SOCs (Middleton's and Ennis) conflicts at SOCs occur for 50% of the arriving MTBs at FC use levels of between 5 and 10 FC per 15-minute interval. At shorter SOCs this probability occurs at slightly high use levels; 10-15 FC. When the typical wait duration is considered, average waits of about 5 minutes for each MTB trip arrival occurs when FC use levels are between about 5 and 10 FC per 15-minute interval.

If for any conflict management and for recreation resource value management reason an "acceptability threshold" for average waits of 5 minutes for <u>all</u> arriving MTBs was established, Figures 30 and 45-48 indicate that the "conflict threshold" would occur from about 2 to 38 FC per 15-minute interval in these example SOCs. This "conflict threshold" would allow each MTB to wait an average of 5 minutes at

each of those SOCs in both operational directions. If extended to all SOCs on MTB trips this is a regime that probably would lead to relatively high MTB passenger, MTB operator, and FC use dissatisfaction. In general, physical saturation occurs at moderate FC use levels and any reasonable standard for "acceptable waits" adopted for resource conflict and safety risk-related conflict management purposes would probably occur at relatively low FC use levels.

c) Study Reach MRS Safety Risks; The SR/C Curves of individual SOC/scenarios can be used in conjunction with the MTB itinerary schedule and FC Use Distribution Model to estimate the influence general FC use levels may have on BS/C issues. In the Hellgate Study Reach results of the SR/C Model indicates that at 1992 FC use levels (and 1992 conditions) the total MRS MOs are 316 and 244 for low and high flow conditions respectively. Various hypothetical FC use levels can be simulated over the entire study reach by artificially increasing and decreasing the magnitudes of the UUCs. By running the SR/C Model for a series of hypothetical FC use levels the changes from 1992 MRS MOs can be used to establish a relationship between BS/C issues and general FC use levels.

The results of the analysis indicate that when all MRS MTB trips are considered, total MOs are sensitive to changes in FC use levels and the degree of sensitivity changes with FC use level magnitudes. As an example for the Hellgate Study Reach Figure 49A shows that under high flow conditions a 100% increase in FC use levels from 50% to 100% of 1992 FC uses results in a 69% increase in MRS MOs (144 to 244), a 100% increase in FC use levels from 100% to 200% of 1992 FC uses results in a 59% increase in MRS MOs (244 to 387), and a 200% increase in FC use levels from 100% to 300% of 1992 uses results in a 102% increase in MRS MOs (244 to 518). With higher FC use levels there is a declining degree of safety risk response.

The 1991 FC use levels were estimated to be about 40% greater than the FC use levels observed during the 1992 BS/C Study field season. This SR/C modeling assessment indicates that the MRS MOs for 1991 would be about 25% and 27% greater than those for 1992 for high and low flow conditions respectively (244 v. 305, and 316 v. 401).

This relationship between increasing FC and MRS MOs, which also applies to low flow conditions, demonstrates a steady reduction in the rate of increasing MRS MOs with increasing FC use levels. This indicates that as FC use levels increase, FC are increasingly more likely to be observed in SOCs from the RIPs by MTB operators and as a result an increasing number of MTB SOC runs are interrupted by stops to accommodate FC. The relative flattening of the MRS MO curves over the hypothetical FC use range reflects a progressive increase in safety risk-related conflicts at SOCs resulting from wait incidents. Therefore with increasing FC use levels the BS/C problems associated with MTBs running SOCs progressively shift from MOs and safety risks, to wait incidents and safety risk-related conflicts.

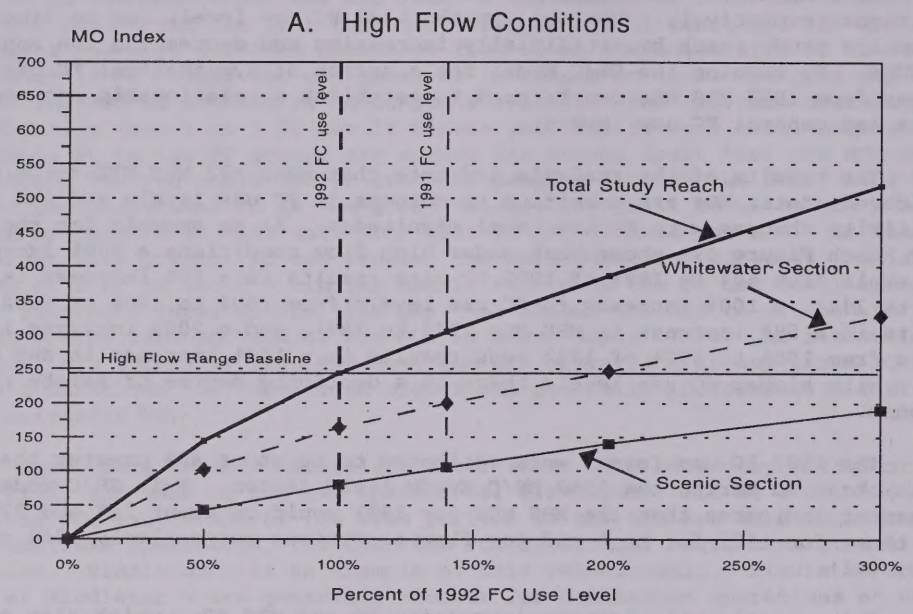
The MRS MO results shown on Figure 49 generally reflect earlier BS/C Study findings. Specifically, over the hypothetical FC use level range, for the whole Hellgate Study Reach for the whole MRS, the degree of potential safety risk exposure is greater under low flow conditions. The high flow/low flow safety risk relationships apply to the two separate sections as well but the Whitewater Section appears to be relatively insensitive to flow conditions. At each use level the estimated MOs are generally only 2-3% lower under high flow conditions. Conversely safety risk exposure in the Scenic Section is very sensitive to flow conditions with about 74-84% MO increases under low flow conditions over the FC use level range. These conclusions generally conflict with FG member perceptions of safety risk which included that: 1) under typical MRS flows (high flow range), the Whitewater Section is substantially more hazardous than the Scenic Section; 2) at low flows the safety risks in the Whitewater Section increase; 3) the safety risks in the Scenic Section are not significant under typical MRS flow conditions (high flow range); and, 4) safety risks in the Scenic Section do not change significantly under low flows.

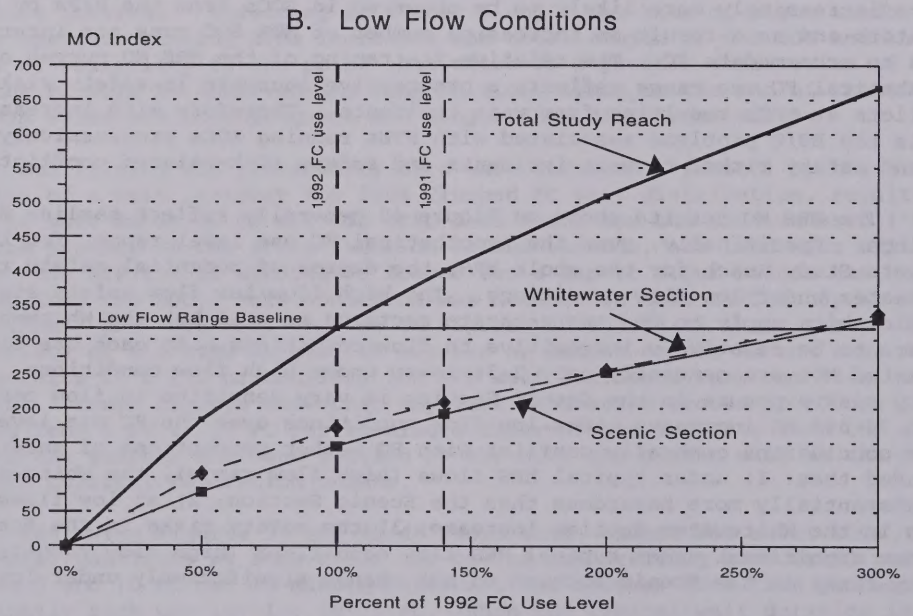
It should be kept in mind that the MRS MO conclusions drawn here refer to total safety risk exposure over the MRS. On a MTB trip-by-trip basis the rates of safety risk exposure realized on MTB trips in the Whitewater Section are higher than on MTB trips in the Scenic Section (See Table 5).

Although at high flows there is a general positive slope relationship between MRS MOs and FC use levels for both study reach sections, the individual SR/C Curves for the specific SOC/scenarios indicate a more complex relationship. Comparing the

Figure 49
Safety Risk Implications of Variable FC Use Levels by Flow Condition

Hellgate Study Reach

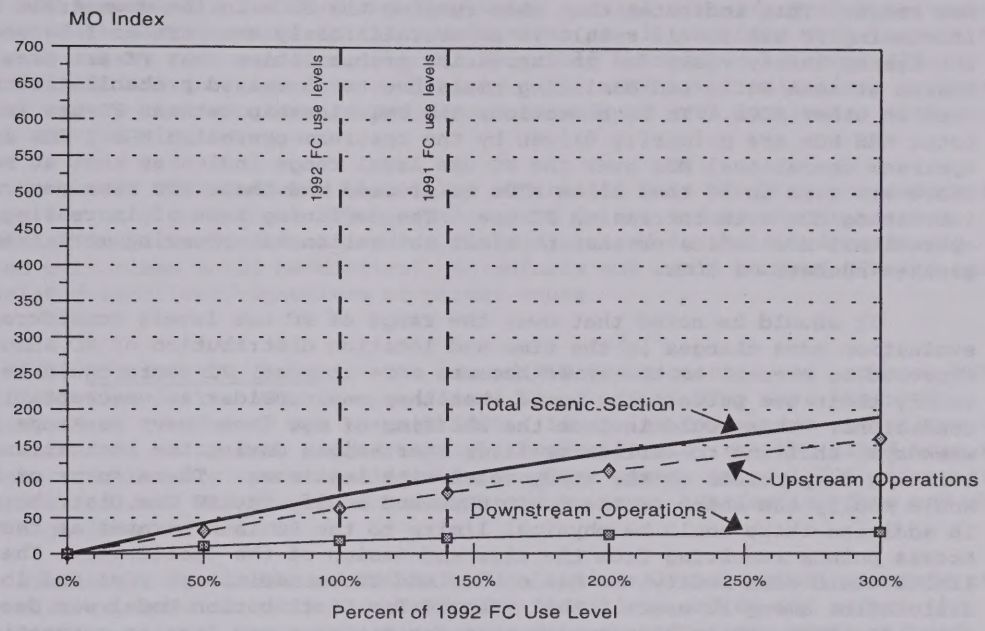




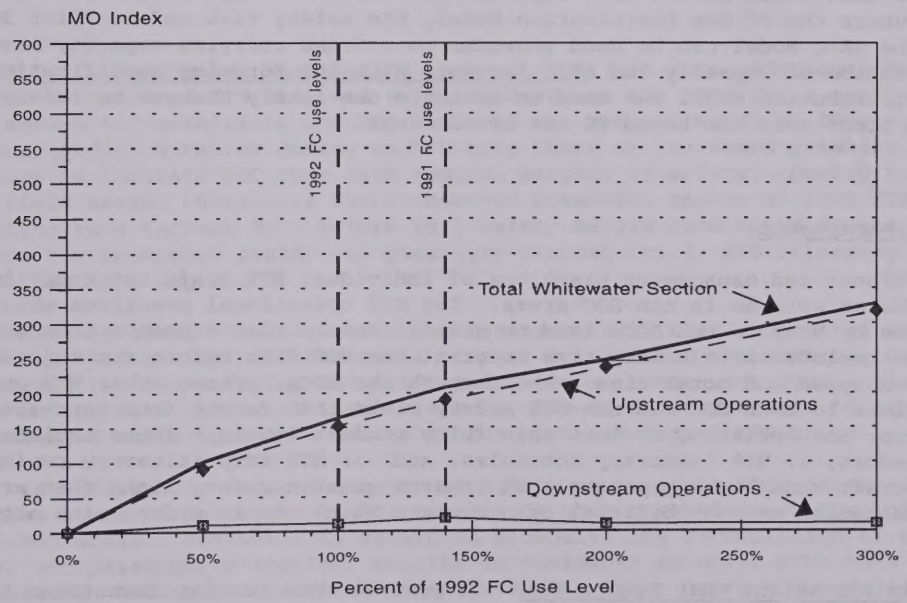
Scenario Conditions:
1992 MTB Schedules,
1992 Management,
1992 River Conditions
Final Safety Risk Parameters

Figure 50
Safety Risk Implications of Variable FC Use Levels by MTB Operational Direction
Hellgate Study Reach - High Flow Conditions

A. Scenic Section



B. Whitewater Section



Scenario Conditions:
1992 MTB Schedules,
1992 Management,
1992 River Conditions
Final Safety Risk Parameters

upstream and downstream MTB operational directions in Figures 30 and 45-48 shows that downstream operational PMOs peak at relatively low FC use levels and declines relatively soon to low levels due to increasing wait incidents. For upstream MTB operations, PMOs increase steadily to high levels through a range of moderate FC use levels and then drop suddenly to zero when physical saturation occurs. These curve relationships indicate that with general increased FC use in the study reach, overall increasing MRS MOs may be due to the rate at which increasing upstream operational MOs override declining downstream operational MOs.

Figure 50 shows the influences that MTB operational direction have on total MRS MOs in the two study reach sections. In both sections the downstream operational MOs stay at very low and relatively constant levels throughout the FC use range. This indicates that when running the SOCs in the downstream direction, increasing FC use levels result in an overall fairly even tradeoff between increasing safety risks due to increasing probabilities that FC are present and are unseen at some SOCs, and declining risks due to increased probabilities that FC are seen at other SOCs. In both sections the relationship between FC use levels and total MRS MOs are primarily driven by the upstream operation MOs. The increasing upstream operational MOs over the FC use level range indicates that at many SOCs there are gaps in FC that allow MTBs to proceed and these MTB runs generate increasing MOs with increasing FC use. The declining rate of increasing upstream operational MOs indicates that physical saturation is occurring more frequently at greater numbers of SOCs.

It should be noted that over the range of FC use levels considered in this evaluation some changes in the time and location distribution of FC should be expected to occur. As the river becomes more crowded, FC users could be expected to modify their use patterns to avoid what they may consider as unacceptable conditions. This could include the shifting of use from heavy weekends to lighter weekdays, shifting to earlier or later start-times during the recreation day, and shifting to portions of the study reach with less uses. These forms of dislocation would modify the shape of the basic UUCs and modify the FC Use Distribution Model. In addition there could be physical limits to the FC launch rates at the various access points resulting from the size and design of the facilities. These capacity limits could also modify the basic UUCs and cause additional time and location dislocation among FC users. While the FC Use Distribution Model was designed to allow FC user pattern adjustments that are either overt (due to recreation management decisions) or inadvertent (due to user pattern shifts), no effort was made in this BS/C model assessment to change the UUC shapes to account for possible shifts that would result from hypothetical FC use levels. Should it be desired in the future the FC Use Distribution Model, the safety risk and conflict SOC curves, and the SR/C Model can be used together to address carrying capacity issues and the interaction of capacity and BS/C issues. With the forgoing qualifications the FC Use Distribution Model was used to estimate the likely changes to safety risks that could occur over the broad FC use level range.

5) MTB Craft Management:

Operational and management practices of individual MTB craft can contribute to BS/C issues in SOCs as well as in non-SOC areas. Two MTB operational practices which relate to the time taken by MTBs to run SOCs lead to greater safety risk exposure than may otherwise occur. These include: 1) MTB stop time spent at the SOC RIPs before run initiation; and, 2) the MTB run speed and total time taken through the SOCs. Three other MTB operational practices relate to both SOC and non-SOS safety risks that result from increased propensity for human error and operating at less than fully prudent levels. These include: 1) passenger comfort; 2) MTB itinerary schedules; and, 3) MTB trip itinerary regime. Finally a sixth MTB craft management practice that imparts greater safety risks than are necessary is the communication responsibilities of operators which can interfere with attentive craft operations.

a) Modifications that Reduce MOs; In general when running downstream the slower MTBs transit the SOCs and the more time expended by MTBs to reach the ST the greater the opportunity for any unseen FC to float to the ST. The first practice that has an influence on this issue is the typical MTB wait times at or above the RIPs before initiating SOC runs and the second is operational speeds. If on a regular basis both of these operational practices were used in a way that reduces safety risks, the SR/C Model outputs would reflect reduced MRS MOs.

i) MTB SOC Wait Times*; As mentioned elsewhere, MTB and pvt-JB operators rely too heavily on the approach visibility for evidence of FC in the SOC ahead. In most cases MTB and FC float speed relationships make the RIPs the most critical LOS location despite often very long approach visibilities. When FC are not observed during the approach and/or at the RIPs, MTBs and pvt-JBs usually initiate a run directly into the SOCs. Exceptions to this MTB operational approach were observed only at Hog Creek Island, Hellgate Riffle, Dunn Riffle, and Lower Galice Chute where MTB operators extended the approach time by engaging in interpretation while off-plane. The SOC Assessments indicated that only at Dunn and Lower Galice were these additional wait times long enough to reduce safety risks from those that would have resulted by using the RIPs only.

SOC Assessments and SR/C modeling using initial SOC safety risk parameters indicate that if MTBs maximized their wait times at all the SOCs with respect to minimizing safety risk exposure, the MRS MOs could be reduced by about 27% for low flow and about 19% for high flow conditions. The additional wait times necessary to minimize safety risk exposure ranged from 3 seconds to over 14 minutes with most SOCs in the 1-5 minute range.

It should be remembered that these additional wait times reduce safety risk exposure for only downstream MTB operations and do not reduce the downstream operational non-time dependent pop-out risks discussed in the SOC Assessments. Required wait times would be difficult to enforce and would subject MTBs to safety risk-related conflicts regardless of direct cause.

ii) MTB SOC Run Times*; The second MTB practice that can increase MTB operational time in the SOCs is operational speed. Most MTBs were observed operating at 25 to over 40 mph through SOCs. If during downstream operations MTB speeds were held at 20 mph, judged through observations by the WRC field team to be the slowest reasonably operationally safe on-plane speed, initial SOC safety risk parameters indicate MRS MOs could be decreased by about 10% for low flow and about 6% for high flow conditions.

Similar to the increased SOC RIP stops, these slower operating speeds reduce safety risk exposure for only downstream MTB operations and do not reduce the downstream operational pop-out risks discussed in the SOC Assessments. Speed restrictions are difficult to enforce and would expose any managing agency to potential liability should an accident occur, whether it be a MTB/FC encounter accident or a MTB navigational accident.

b) MTB Craft Management that Result in Overt MOs; At SOCs additional BS/C issues occur as a result of MTB stop and wait incidents at the RIPs for a gap between FC large enough to re-initiate the SOC run. As unscheduled waits at SOCs increase in frequency and/or duration during an MTB trip there is increased pressure on MTB operators to initiate SOC runs with reduced margins of safety. During the 1992 BS/C Study field season there were three observed potential causes of lead MTBs initiating runs through SOCs before full safety margin conditions developed (FC clear of the knowledge field): 1) passenger discomfort; 2) MTB itinerary schedule; and, 3) MTB trip regime.

Each of these three elements can interact to further reduce the margins of safety employed at the SOCs because a stop at any SOC for whatever reason reduces the flexibility for stopping and prolonged waits at subsequent SOCs. Also because of the interactive nature of these elements, the greatest pressure to avoid stopping and prolonged waits typically occurs on the upstream leg of MTB trips

In addition to reduced margins of safety employed at SOCs these same elements have been observed to result in MTB operations that created Overt MOs and conflicts in non-SOC areas. Pressures to return on schedule, the accumulation of unexpected delays, and passenger discomfort results in incidents in which MTBs pass FC on-plane at separation distances too close to avoid BS/C. These Overt MOs were identified by WRC field staff though the reaction of FC users to the MTB pass (gestures, epithets, and arguments) and the spatial criteria for acceptable MTB passes developed by the FG.

i) Passenger Comfort*; When MTBs are stopped at SOCs waiting for a chance to re-initiate a run, after about 5 minutes passengers were observed during the field season to begin displaying behavior patterns indicating a reduction in wait-tolerance. These behavior patterns included squeamishness in the seats and

scattered comments of mild exasperation at the FC user patterns that prevent MTB run re-initiation. Well before the wait duration at a SOC reaches 15 minutes some passengers were observed to make derisive comments toward FC users and their discourteousness, to be impatient with the apparent excessive margins of safety being employed by the MTB operator, and to engage in coaxing the operator to proceed into the SOC in spite of the observed FC. These behavior responses probably result from boredom and restlessness associated with long periods of passenger inactivity while sitting in the MTB, issues of resource conflict with FC users who are perceived to cause the wait incident and its duration, and the comfort level of passengers. Under these conditions, particularly if long-duration wait incidents occur more than once on a trip, MTB operators may be put under pressure to proceed through SOCs using reduced margins of safety.

Passenger comfort levels on these MTB trips are adversely affected by long periods of time in the MTB, prolonged exposure to direct sun on hot days, prolonged exposure to wind and rain on cool, poor weather days, seats with insufficient padding, lack of rest stop opportunities (particularly following meal stops), and thirst, etc. On the Whitewater MTB trips, except on cool or rainy days, these discomfort elements are aggravated by the MTB owner/operator requirement that passengers wear PFDs.

Increased effort and concern for passenger comfort could reduce the pressures on MTB operators to proceed into SOCs at reduced margins of safety and could reduce the recreational resource values conflicts accumulated by MTB passengers during stops. Some of these actions could include providing on-board drinking water, building additional stop time into the trip itinerary schedules to accommodate rest stops at some of the ramps, and deleting the PFD requirement on the Whitewater Section.

ii) MTB Itinerary Schedules*; The second aspect of MTB operations that induce tendencies to run SOCs with reduced margins of safety is the MTB itinerary schedule. In spite of claims that there is considerable flexibility in the schedules that allow for extended waits at SOCs (Figure 31), most of the schedules provide for little turn-around time at Grants Pass before subsequent MTB trip departures. If trips run late due to SOC waits, MTB operators lose that time in their break between trips. In particular the Whitewater trips have tight schedules. These trips run 66.6 miles round trip in about 5 hours with a 1-1.5 hr. meal break at a point about one quarter of the way up the return leg. The AM Whitewater trip returns to Grants Pass during the period of 1200-1400 hrs., a period of high FC use activity. After returning to Grants Pass there is a one hour layover for the operators before the PM Whitewater trip is scheduled to depart. AM Whitewater trip returns are under particular pressure because of this short break. PM Whitewater trips return to Grants Pass in the period of 1900-2030 hrs. and are under pressure to reach Grants Pass before adequate light is lost. Similar lighting related pressures exist for the returning Dinner trips. Several incidents were observed in which MTB operators showed impatience with FC in SOCs when the MTB operators perceived that these activities were causing MTB run delays even though the FC were following typical user patterns and simply floating through the SOCs. The MTB operators expressed this impatience and irritation to the FC users by hand and arm gestures and the use of the horn in efforts to get the FC out of the SOC quickly so that the MTB trip could proceed.

In addition to operator pressures to return quickly and to avoid prolonged stops, passengers may have a limited tolerance for trips that run longer than anticipated. This is above and beyond the passenger comfort issues discussed above. The need to stay on schedule results in little additional available time for unexpected wait incidents. This leads to general impatience when waits do occur and the tendency to run through SOCs with less than optimal margins of safety.

iii) MTB Trip Regime; The third cause of increased tendencies to run SOCs with reduced margins of safety is the general regime of the MTB trips themselves. The MTB trips are run primarily to maximize the recreational resource values of the MTB passengers. One aspect of this is the general predisposition of passengers to be interested and absorbed in the river resources early in the trip and to have lagging interest toward the end of the trip. On downstream trip legs MTB operators tend to stop often for interpretation of local natural and human history. As noted above, these stops are sometimes positioned to extend the approach visibility into the top of SOCs. As a result, the downstream legs of trips tend to progress at a relatively slow rate. During the returning upstream legs passengers are generally

less interested in interpretation and the MTB trip regime is generally focused on returning to Grants Pass and providing a few spins. As a result of this general trip regime, during returning trip legs there is less time flexibility built into the schedule to accommodate unanticipated wait stops at SOCs and less passenger tolerance for prolonged waits.

c) Inattentive MTB Operations that Increase Overt MOs; A final aspect of MTB craft operations that influence BS/C issues concerns the number of radios and on-board intercom devices. Existing MTB operations use communication systems involving 3 microphones; 1 FM system to communicate with other MTBs; 1 CB system to communicate with pvt-JBs; and, 1 intercom system to communicate with passengers. Maintaining adequate attention on MTB navigation while also handling the communication systems can be difficult in the Whitewater Section where there are reduced margins of navigational safety and higher levels of FC traffic. Several incidents were observed by the field team in which MTB operators became frustrated and confused with the operations of the communication systems while involved with navigating through SOCs. When running SOCs in areas with concentrated FC uses MTB operator attention to MTB navigation, passenger interpretation, and maintaining radio communications can lead to operator frustration and diminished attention on MTB craft operational control which could result in improper judgement, decisions, and human error, and to increases in safety risk exposures from Overt MOs.

Reduced potential for Overt MOs would result with changes in the MTB operational approaches that reduce the involvement of the operator in passenger management and interpretation, and increased attention toward craft navigation. This change could include a second MTB operator whose responsibility is solely the interaction with MTB passengers using the intercom system.

6) MTB Convoy Management:

MTB trips sizes vary greatly from a single MTB to 7 craft. The Whitewater trips typically are composed of 1 or 2, and sometimes 3 craft as are the Scenic trips. Brunch trips generally have 3 or 4 MTBs while Dinner trips vary from 3 to 7 boats; 7 craft trips are most common on MRS Dinner trips on weekends, holidays and many of the weekdays. On-river field experience through the 1992 field season and input from the FG revealed FC and other users tend to have difficulty in dealing with multiple MTB convoys that, due to a variety of circumstances, result in irregular and unpredictable gaps between MTB craft. In this context "irregularity" refers to non-motorized recreationists being uninformed as to the arrival of subsequent MTBs in a MTB convoy. Irregular gaps between MTB craft results in a wide range of potential BS/C issues. The causes of irregular gaps in MTB convoys and other BS/C issues associated with convoy management include: 1) the numbering system employed to identify the number of craft in the convoy; 2) the number and spacing of craft in the convoy; and, 3) the intermingling of separate MTB trips and convoys.

a) MTB Trip Size Numbering System*; The commercial MTB owner/operator has adopted a trip size numbering system to inform FC users and other users as to the number of MTBs on a trip and to assist non-motorized users in accommodating passing MTB trips. This system involves a lead boat craft number "flag" that displays the total number of craft in the trip. The number flag is an aluminum sheet approximately 1 ft. X 1 ft. painted with a black numeral and mounted on a 2 ft., shaft and fitted into the railing on the MTB fantail.

Most often other general river recreationists, particularly those that are infrequent Rogue River users, do not notice the lead MTB craft number flag, or do not understand the meaning of the number flags, and do not know how many additional MTBs to expect. If it is the FC user's first exposure to MTBs they may not expect any additional MTBs and move directly back into the main channel as soon as the lead MTB has passed. This generally poor rate of MTB number flag observation by on-river recreationists usually results from: 1) not knowing that the craft number information is displayed on these flags; 2) attention is diverted from the number flag by the MTB operator's desire to start a wave-response cycle between the other users and the MTB passengers; or, 3) attention is diverted by simply the size, speed, noise, and the busy and cluttered craft lettering and paint schemes of the passing MTBs.

It was also occasionally observed that the lead MTB boat with the number flag will be passed by other MTBs in the convoy. When this occurs the first MTB

encountered by FC and other users does not have a number flag and FC users, even those who understand the system, will not know about the trip size. The causes for the lead boat dropping back in the convoy include stopping to clear pumps, extended interpretation stops, and casual operational practices on the part of operators, etc.

On-river observations also indicate that even when other river users do see the lead boat craft number flag and understand its meaning, after the passage of about the fourth MTB craft there was a notable tendency toward memory degradation as to the number of MTBs that have passed and have yet to pass. This was repeatedly experienced when WRC field staff were paddling in the study reach and was reported by the pvt-JB operator of the FG (Appendix K, 157). This process is particularly acute if there are substantial and/or irregular time gaps between individual MTB craft of the convoy.

b) MTB Convoy Size and Craft Separation*; MTB groups, primarily in the Scenic Section, tend to run in loose convoys. Gaps between individual MTBs can vary between less than 1 minute to almost 20 minutes. Gaps larger than 2-3 minutes between MTBs introduce uncertainty into the activities of those other river recreationists that are trying to accommodate passing MTB groups. When operating with 2-3 minute gaps there are only rare places on the study reach where 2 on-plane MTBs can be seen or heard at the same time. Therefore FC and other users are inclined to resume activities between MTB passes when gaps of 2-3 minutes or greater exist. It is a stated goal of the MTB operator's to operate just out of sight from the other MTBs in the convoy to provide a isolated recreational experience for their passengers (ibid., 58). This results in gaps between MTBs that can cause uncertainty for FC users.

When gaps between MTBs are irregular and uncertain, other on-river users that are accommodating MTB trip passages cannot determine at what point no additional MTBs are approaching and may be just resuming their recreational activities when additional MTBs arrive at their location. In non-SOC areas this can result in recurrent recreation resource conflicts and at SOCs can result in safety risks if FC have entered a SOC when these additional MTBs arrive. If MTBs are run in tight well organized convoys with significant time gaps between MTB trips and convoys, FC and other river users can more easily accommodate the MTB convoy passage and then resume their own activities. From general on-river observations by WRC it appears that a well defined gap of at least 30 minutes between MTB trips is sufficient to allow most users to accommodate the MTB trip passage, return to their own activities, and accomplish an adequate increment of recreational activity before another MTB trip arrives. Convoy gaps of at least 30 minutes can allow convoy accommodation by other users without incurring aggravated safety risk exposure or resource conflict problems.

On-river observations indicate that MTB trips with 2-4 (and occasionally even 5) craft tend to operate as a tight convoy with a total trip passing time of 5-7 minutes with fairly tight and regular spacing between craft. However when MTB trips are composed of 5-7 craft the groups tend to break up into 2 or more sub-convoys with irregular gaps between boats ranging from 1 to nearly 20 minutes and a total trip passing time of 20-30 minutes. In the former situation, when the MTBs are in a tight group, other on-river users are better able to accommodate MTB trips, can adequately deal with wake/safety consequences during the MTB trip passage, and, after MTB trip passage, can resume their own activities at their own pace. In the latter situation, the spacing and gaps between MTB craft passes creates uncertainty as to when the next MTB will pass and when the last has finally passed. For FC and other users, this makes the "conflict cost" of accommodating the passing MTB trip much higher. It also may contribute to FC entering SOCs inadvertently during MTB trip passes.

The gap between MTBs also affect the reliability of FC information passed between MTBs by radio. Continuous observations of FC activities at various locations showed that as little as 5 minutes is required to change the FC use distribution significantly enough to render older radio communications inaccurate. This is particularly true in multiple channel areas where operators of previous MTBs may not observe all FC in the area, or at access ramps where FC groups have been observed to arrive, launch, and enter SOCs in less than 5 minutes. Therefore with respect to BS/C issues, information on FC activity patterns obtained by another MTB more than 5 minutes ahead can be highly degraded. MTBs following in the convoy group with more than a 5 minute gap ahead should be operated as a lead craft using all the necessary lead craft operational precautions.

The tendencies for MTB convoys to operate with large gaps between individual craft and to break into separate convoy pods results from general channel characteristics as well as operator/management decisions. In reaches of river with short and/or infrequent effective set-down areas the gaps between craft tend to be longer and the disaggregation of the convoy into separate operational pods occurs with fewer craft. In the Whitewater Section, narrower channels and the more technical nature of the hydraulics indicate that the maximum convoy size that can operate as a single aggregated unit is 3 craft. In this section, the distribution of available set-down areas, SOCs and the potential MTB wait times due to FC use levels indicate that it would be difficult for 4 individual MTB craft to operate as a single convoy.

The straighter, longer channel characteristics of the Scenic Section, along with the larger and more frequent effective set-down areas indicate that larger MTB convoys can operate as a single entity and that there can be shorter gaps between individual craft. On-river observations in the Scenic Section indicate that when there are more than 4-5 craft in a single MTB trip, the number of MTB craft becomes too large to effectively manage as a single entity. Formally (by intent) or informally (as a natural operator adjustment) these groups tend to split into 2 "subconvoys" often with the last 2 or 3 MTBs operating as a subconvoy with as much as a 15-20 minute gap behind the first group of MTBs. The most common formal split trip scenarios involve the Dinner trips when 7 MTBs split into 2 convoys of 5 and 2 MTBs each. Other large MTB trips split into several convoys informally and gaps between craft can range for 1 minute to nearly 20 minutes and are irregular and unpredictable. The total elapsed time required for MTB trips like this to pass a given point on the river can be 20 to 30 minutes. In these situations the spacing and gaps between MTB craft passes create uncertainty on the part of other users as to when the next MTB will pass and when the last has finally passed. This uncertainty in itself contributes to resource conflicts for those users trying to accommodate MTB convoys. If these users resume their activities in the middle of a MTB convoys, subsequent MTB arrivals can result in additional safety and conflict problems.

c) Convoy Intermingling*; The last aspect of MTB convoy management that creates uncertainty and potential BS/C issues is the overlapping and intermingling of separate MTB trips. During the MRS, MTB activity is fairly constant throughout the Hellgate Study Reach, and particularly heavy in the Scenic Section. The safety risk and conflict aspects of the all-day, every-day MTB itineraries, and relatively high number of daily MTB craft passes can be particularly aggravated in the Scenic Section by the short gaps or intermingling between itineraries on the return legs of the afternoon and evening trips. Afternoon Whitewater trips, evening Dinner trips, and even special PM Scenic trips have been observed to intermingle and/or be close enough to effectively act as one strung out trip varying in size from 3 to more than 10 MTB craft. When separate MTB trip itineraries get too close together or intermingle, no semblance of individual trips or convoys is maintained. This leads to situations in which gaps between MTB craft are highly irregular and boats carrying the craft number flags are scattered throughout the intermingled group. Under these conditions other on-river users have no reliable information on the time gaps between MTBs or when the last MTB has passed a specific location. This leads to prolonged periods of uncertainty as to MTB activity.

7) Recreation Management:

Over the 3 year period 1990-1993 the BLM reports that annual visitation by watercraft users has averaged about 120,000 visitors on about 25,000 craft trips (all types) (Walker pers. comm.). For rivers with similar channel/hydraulic conditions and with similar activity types, these annual visitation rates place the Hellgate Study Reach among the most heavily used river recreational resources in the U.S. In addition to the relatively high use levels, the mix of use activity types in the study reach is shown by the SOC Assessments and SR/C Model to result in safety risks and safety risk-related conflicts. These activity types include boat, bank, and bed angling, rafting and floating using a variety of craft, wading and swimming, and motorized boating etc.

The nature of MTB/FC interactions are such that at relatively low FC user levels there can be high probabilities for MOs and safety risk-related conflicts. The relatively high estimated probabilities for safety risk and conflict encounters and the conflict-inducing size, speed, and impact disparity between MTBs and FC (and other users) indicate that the recreation setting in the study reach has real, latent, and potential BS/C and resource conflict issues. When a river recreation setting has these conflict

characteristics and includes over 110,000 users a year, active recreation management is of prime importance. Without active management it is unreasonable to expect that the activity mix at the present use levels can naturally find a degree of coexistence that provides all parties with relatively equal resource values and exposures to real and perceived safety risks and safety risk-related conflicts.

On-river observations and input from the FG identified several aspects of recreation management that aggravate BS/C issues. These management concerns include: 1) the lack of regular on-river enforcement (county sheriff's Marine Deputy) and management (BLM) patrols; 2) present enforcement efforts tend to concentrate on law enforcement rather than interpretation, communication and cooperation; 3) insufficient and uncoordinated incident reporting procedures for situations involving MTBs; 4) the lack of structured off-season interaction between MTB/pvt-JB operators and FC and bed and bank users designed to increase awareness of, and education on, BS/C issues; and, 5) the lack of active on-river recreation management of MTB operations with respect to BS/C concerns.

a) On-River Management/Enforcement Patrols*; During the 1992 field season which included over 90 field days, only a few management/enforcement patrols were observed. The observed Sheriff's (enforcement) patrols included as many as 6 JB patrols through most of the entire study reach and in the latter half of the field season daily driftboat trips between Grants Pass and Robertson Bridge in the Scenic Section. No official BLM (management) patrols were observed but the BLM has reported conducting approximately 4 administrative trips per month in the May-September period. These trips include ramp patrols, user data collection days, and compliance patrols. These administrative trips do not meet the basic criteria for management presence that targets user contact.

The paucity of enforcement and management presence on this resource is a very important element in the recreation setting and may contribute to aggravated conflict and safety risk issues between the activity types. Without on-river enforcement or management presence FC and other non-motorized users who have experienced real or perceived safety risk exposure or conflicts have no convenient nor informal avenue with which to present concerns. Conversely JB and MTB operators have no convenient avenue within which to defend or explain the nature of the situation to either the other user or enforcement/management personnel. This situation leads to an environment in which all users can be separated from the management of the resource.

With regular and frequent, if not daily, management/enforcement patrols, users and management personnel would have the opportunity to interact during the course of recreational activities. This would provide the opportunity for recreational users to contact managing agencies about BS/C incidents and to have those incidents and concerns addressed on-river by an agency representative.

The on-river enforcement presence is seen by members of the FG as being very infrequent and focused on enforcement and citation issuance for such things as PFD possession, fishing license possession, and no-anchor regulations, etc. rather than on information, education, and "soft-enforcement". To improve the general BS/C conditions through on-river patrols it is important that these patrols: 1) contact and relate to users as recreationists using low-keyed public relations demeanor; 2) assist in purveying educational information on safety, conflict, and accommodating behavior, etc.; 3) engage in rule enforcement using "soft" techniques; 4) enhance communications and interaction between user activity types; 5) provide information about river management efforts; and 6) provide quick response in resolving on-river safety risk/conflict situations.

b) Incident Reporting*; There are three agencies that require MTB incident reports for a variety of situations and one agency that receives complaint forms voluntarily from users. The various agency incident reporting requirements use different circumstances for thresholds to identify reportable situations. Each agency collects their incident reports with little sharing of reports. As a result the agencies have limited breadth of incident knowledge and the members of the public interested in incident situations are frustrated when trying to obtain information. In addition, non-accident situations that clearly had potential for BS/C issue are not reportable in any of the formal agency incident procedures. With this situation it is not possible to build an incident data base sufficient to evaluate the real level of BS/C issues in the study reach.

Commercial MTB operations submit incident reports to the US Coast Guard (USCG), the Oregon State Marine Board (OSMB), and the BLM. While all of these

reporting systems have the intent of reporting incidents and accidents involving JBs and MTBs etc. the procedures particular to each system often result in reporting different incidents to different agencies. Along with some uncertainty as to the precise threshold conditions which define a reportable incident for each agency, the multi-agency reporting systems create a confusing incident reporting melange. This is a situation in which the MTB operators and the MTB owner/operator are unsure as to which incidents should be reported to which agency. In addition management and enforcement agencies are not totally assured that all reportable incidents have been reported and are not fully aware of incidents reported to other agencies.

The confusion over the various incident reporting systems and the lack of uniform and coordinated reporting system can induce insecurity and suspicion of the reporting system. Members of the FG and statements in the local press have expressed questions as to the reliability of the information contained in the reports indicating that the information comes from one side of the incident and reflects the views of that party. There is concern that the agency responses to the reported incidents are either inadequate or overzealous depending on the perspective. The fragmented incident reporting system can put the various agencies and their management approaches under a cloud of suspicion that they may be diminishing the nature and severity of accidents involving MTBs.

The USCG requires reports when any commercial power craft on navigable waters of the U.S. is involved in a variety of incidents. The Hellgate Study Reach is formally designated a navigable waterway. The USCG recognizes that MTBs are designed and intended to occasionally hit the channel bed in the normal course of operations so not all contacts with the channel bottom or bank are considered reportable. The USCG requires that all "unintentional groundings" are reported. Unintentional groundings are defined as those accidental incidents that occur "during the course of normal operations" and result in at least a "slowing of progress".

The appropriate separation of "unintentional groundings" from those groundings that do not require reporting (intentional groundings and unintentional grounds that do not 'slow progress') is an important aspect of the USCG incident reporting procedures. This requires a clear understanding of what constitutes an "unintentional grounding". With respect to making contact with the channel bed during the normal conduct of operations, how much of a "slowing of forward progress" is required before it is a reportable incident. The possible changes of boat speed that can occur when hitting the bed or rocks can range from only the sound or a momentary shock upon impact, along a continuum to a condition in which a near stop occurs with passengers and/or operators thrown from their positions. What would be considered by one person as a serious grounding that slowed forward progress, may be considered as an exciting aspect of a JB ride to another. There is no clearly prescribed threshold for "slowing of forward progress" that is used to determine reportable groundings.

Grounding could include situations in which a MTB hits the bank in the course of an operator avoiding other craft or on-river users (and does not sustain the necessary property damage of injury to stimulate an incident report). The USCG may consider this an 'intentional grounding' not requiring an incident report. Other agencies or users may consider this an incident of paramount importance and bearing on BS/C concerns necessitating a formal report.

The USCG $25,000 property damage threshold may not provide a consistent common denominator for incident reporting. As an example the commercial MTB operation on the study reach is essentially self-contained; with numerous operators, employees experienced in building and repairing MTBs, and fabrication facilities, etc. Any damaged MTB craft could be salvaged, transported and repaired within the operation itself. An operation without these full service capabilities may have to expend more funds for repair for the same level of physical damage. This would result in a lower physical damage threshold for incident reporting. In addition there is the question that a $25,000 damage threshold may be inappropriately high for a recreation setting like the study reach. Due to these factors many incidents and accidents involving JB/MTB safety risks, etc. may go unreported to the USCG.

Oregon state law and the OSMB administrative rules require boating accident reports for incidents involving any recreational craft (except USCG inspected commercial craft) which result in death, injury requiring medical attention beyond first aid, or property damage of more than $500. Accident reports are not required for conflict or incidents involving evasive maneuvers or potential safety problems when injury, death, or $500 or more in property damage do not occur. Groundings of

any kind, so long as they do not involve injury, death, nor more than $500 in property damage are not reportable incidents. However, any boat operator may prepare and file an accident report with the OSMB regardless of the severity of the incident.

Of those circumstances requiring incident reports there is some confusion as to the level of injury which is "requiring medical attention beyond first aid". Medical attention could range from on-board first aid, seeking post-trip medical review of first aid treatment without the need for additional treatment, seeking post-trip medical review of first aid treatment that leads to changes in first aid treatment, to post-trip medical treatment above and beyond the first aid care. These are various points on a continuum of injury attention and the line that separates reportable from non-reportable incidents is not necessarily well understood by all parties concerned with MTB safety issues.

With regard to the $500 dollar property damage threshold, the same concerns expressed under the USCG requirements apply to the OSMB; that with a self-sufficient operation, $500 in damage to MTBs could involve significantly greater levels of physical damage than if the repairs were undertaken by outside commercial entities.

Finally while the OSMB incident reporting procedures apply to all recreational craft, they may not apply to about 2/3 of the MTBs in the study reach because they are inspected by the USCG. Presently however, there is an informal agreement between the MTB owner/operator and the OSMB that accident reports will be filed for incidents involving any of the MTBs that meet the OSMB reporting thresholds.

The BLM incident reporting process uses the same criteria as the OSMB for determining "reportable incidents" and the same concerns and problems apply. The BLM incident reporting process applies however, to all commercially permitted craft operating in the Applegate to Grave Creek portion of the study reach. Therefore accidents involving non-commercial craft and accidents involving commercial craft above the Applegate River confluence would not be covered in the BLM procedures.

On a river with Class I to III- riffles and rapids, with MTBs and FC uses in which MOs are probable, and where 40-80 MTB passengers are being transported at high speeds through rapids, any and all MTB groundings should be reportable incidents. The USCG considers MTB uses as a commerce and trade industry and has relatively lenient thresholds for incident reporting. Even though the MTB operation generates profit and creates employment, it provides only recreational services on an exclusively recreational reach of river. The fundamental objectives of, and causes for all users on this study reach are recreation based. In that regard there is a need for a reporting systems that collects incident data on all situations that are BS/C related. This should include: 1) all groundings of MTBs and pvt-JBs; and, 2) any emergency evasive maneuvers conducted in SOCs to avoid other users regardless of outcome.

c) Safety/Conflict Meetings*; Various members of the FG, particularly the MTB operator member, commented on the very poor level of on and off-river communications between users of the various activity types. It was noted in the FG meetings that this lack of on-river communication leads to more difficult boating conditions when, at SOCs or other on-river locations, craft operators do not know the intentions or desires of other craft operators. Even among those that use the resource daily or weekly, very few know anyone in any of the other user activity groups. Lack of personal familiarity leads to lack of communication, lack of understanding, increased user activity type division, increased animosity, and further pressures against communication. This is a cycle that can maintain a poor safety risk and conflict situation in the study reach.

On a river with clearly divergent activity types with the potential for resource conflicts and the potential for BS/C incidents regular safety/conflict meetings could be a very important facet of recreation management. Regular SR/C meetings involving key representatives of the various user activity types, could lead to the discussion and resolution of safety/conflict issues, develop out-reach to the general bodies of the represented activity type groups, and could be a central catalyst for generating communication among user groups.

d) Active Agency MTB Management; The results of this BS/C Study indicates that: 1) there are real safety concerns with MTB operations through most of the SOCs; 2) that

at relatively low FC use levels the probabilities of potential safety risk incidents are relatively high; and, 3) that at relatively low FC use levels the probabilities that safety risk-related conflicts will occur at the SOCs climbs very quickly. As a result of these findings the management of MTB operations should be of the highest priority for the river managing agency.

While the MTB owner/operator was involved with the cosponsoring agencies during the development of the BS/C Study scope (Walker pers. comm.), BLM did not secure an agreement with the MTB owner/operator to cooperate with the BS/C Study itself. In addition, the MTB owner/operator's commercial permit with BLM does not have a provision to allow BLM personnel to secure rides on MTBs for SR/C review purposes (Leffmann pers. comm.; USDI BLM 1994). The MTB commercial permit did not provide for open access to the MTBs for the purposes of the BS/C Study nor require cooperation with the study. The MTB owner/operator chose not to participate in several very important aspects of the BS/C Study field work and data gathering efforts.

Based on the BS/C results of this study the river managing agency needs to develop an active and pro-active posture with respect to MTB operations. The commercial permits for MTB operations could be modified to allow for the interjection of river management personnel on to MTB trips at any time (Only rarely is every passenger spot booked on every craft of each MTB trip), and to require cooperation in the BS/C assessments. This could include controlled stop tests for all MTBs in use. The managing agency could also actively engage MTB operators in the on-river review of BS/C concerns. At a minimum there needs to be an annual pre-season ground/boat review (jointly conducted by BLM and the MTB operators) of each of the SOCs to firmly establish LOS thresholds and to review FC traffic patterns that the LOS thresholds obscure.

8) General On-River Safety Risk and Conflict Issues:

This BS/C Study risk modeling effort has been targeted at MTB/FC interactions at SOCs but many concerns raised about motorized boating impacts have involved bed and bank angling, and wading and swimming activities. Field observations during the BS/C Study and input from the FG indicate that potential safety risk, safety risk-related conflict, and resource conflict issues between JBs and these user activity types can occur at various non-SOC locations. These potential BS/C issues were not addressed via a modeling approach because they mostly involve locations where MTB operations are not limited by channel characteristics and were, by definition, avoidable. Avoidable safety risks are controlled by operator decisions and are outside the SOC Assessment and SR/C Model parameters.

a) Bed and Bank Angling; Bed and bank angling are relatively popular activities in the study reach particularly in the Scenic Section. While particularly prevalent during the fall Chinook runs, these activities can be found in the study reach nearly year round.

Bed angling involves anglers wading to various depths and to various distances from the channel edge. These users are either fly-anglers or anglers using bait or lures. Due to the channel conditions in the study reach these uses are typically located at riffles where wading allows greater access to deeper water at some distance from the channel edge. Based on individual preference and angling needs, anglers wade to water depths ranging from a few inches to 3-4 ft. To one degree or another these anglers are exposed to the waves generated by MTBs during encounters and, depending of site-specific circumstance, could be exposed to safety risks. To the degree that bed anglers and/or MTBs accommodate each other to avoid safety risks, safety risk-related conflicts occur.

During the 1992 field season bed anglers were observed at several locations in the Scenic Section and at one or two locations in the Whitewater Section. The most often used locations are near easy access points and in the Scenic Section include the riffle below the mouth of the Applegate River (RM 6.7 RR), the tailwater/pool below Whitehorse Riffle (RM 7.6-7.8 RR), Finley Bend (RM 9.5-9.6 RR), Panther Chute (RM 10.4-10.7 RL); and in the Whitewater Section in the RR channel at the top of Carpenter's Island (RM 24.7 RR). Wade angling can also occur in lesser concentrations at many other locations where shallow channel edges allow wading access to deeper fishing waters. When angling demand is heavy, such as during a large anadromous run, wade angling could be expected to occur at many more locations and have greater number of participants than were observed during the 1992 field season.

These users are exposed to the waves of MTBs when these craft pass on-plane. On-plane MTBs generate a series of 5 waves that impinge on the shoreline in quick succession. MTB wave heights were estimated to range from 0.5 to 1.33 ft. (Klingeman, Cordes, and Nam 1993). See Figure 19 for an example. Waves of these heights can cause unstable footing if bed users are in waist deep or deeper water. Further, safety risks can occur if bed users are wearing waders that can be filled with water by the waves. Most bed anglers use waders of varying heights.

Most of the bed angling uses were observed at locations that are not associated with SOCs and MTB operational limiting factors. As a result most safety risks associated with MTB/bed angler encounters are avoidable either by the MTB stopping and drifting past the angler or the anglers wading to shallower channel areas during the MTB approach such that the MTB wake does not create a safety risk threat. Safety problems could occur in situations in which the channel is too shallow to allow the MTBs to pass off-plane and the bed anglers do not move out of the channel enough to allow a safe on-plane pass. In the Scenic Section the most pronounced low flow/high flow channel change is the loss of MTB drifting opportunities at some locations. This can result in greater potential MTB/bed angler safety risks at lower flows. An example is at Panther Chutes where at lower flows anglers can wade nearly to the center of the channel, more than 75 ft. from shore and where downstream operating MTBs cannot stop in the riffle nor drift through it to the pool at the bottom. The potential for safety risks are present when these two user types encounter one another but most often the safety risks can be reduced to safety risk-related conflict when either the MTB goes off-plane and waits before entering the riffle while the angler wades to shallower water.

The two situations where there could be less opportunity to supplant safety risks with safety risk-related conflicts are Applegate and Carpenter's Island. At Applegate wading anglers use the tailwater area of the riffle below the Applegate River confluence. They tend to wade out about 50 ft. from the RR shore to a point where water depths approach 3 ft. and where, near the edge of the tailwater area, there can be substantial water velocities. This is a location adjacent to the tailwater area used by downstream operating MTB to come off-plane after running the riffle below the Applegate River. The wading area is not visible from the downstream running MTB RIP location (See Plates 6 and 7), therefore MTBs can be expected to run this riffle without knowledge of bed angler usage or distribution. While it is not likely that MTBs will directly overrun wading anglers at this location they could generate waves that could put these anglers at risk.

The other location at which safety risks may be unavoidable is at the top of Carpenter's Island where fly-anglers fish the top of the RR channel past the island and access that location by wading the top of the RL channel from the RL bank. The wade crossing of the RL channel crosses the MTB route. For upstream running MTBs some of the RR side of the RL channel may not be fully visible from the RIP location at the bottom of the riffle segment (See Plates 47 and 48) and occasionally wading users could be put at some level of risk associated with MTB waves. Any wading anglers that would be unseen by the upstream running MTB operators in this situation should be in shallow and slow water near the head of the island and should not be put at serious risk.

There is a major recreational resource conflict relationship with the MTB/bed angler encounters. It was reported by the fly-angler member of the FG, and observed by WRC staff, that attached aquatic vegetation is separated from the shallow channel areas by the wave action of passing MTBs and that this debris floats downstream and catches on the fishing lines (Appendix K, 15, 46). The detached vegetation that causes these problems can float significant distances within the angling zone of the channel and anglers report that this vegetation can foul fishing lines for up to 30 minutes after a MTB trip passes an angler. With closely scheduled MTB trips the problem can be repeated several times over a short period of time leaving relatively little fishable time available to anglers. Prime fly-angling is in the morning and evening hours when the angle of light on the water is low. These are the times of day with the greatest MTB trip densities (See Figure 31). This resource conflict problem is reportedly responsible for the dislocation of fly-anglers to other river resources in the region during the MRS (ibid., 46-7, 60).

Based on on-river observations during the 1992 season and input from the FG members it appears that there are few situations in which MTB/wading angler encounters result in unavoidable safety risks. However, due to the relatively high potential rates of safety risk-related conflicts and resource conflicts, incidents of Overt MO safety risk exposure may be induced by uncooperative or confrontational user behavior.

Bank anglers are generally found at a variety of easy access locations and mostly where water is deep adjacent to the shore. Bank conditions at these locations range from gravel bars to scoured bedrock banks and low cut terraces. In the 1992 field season, bank angling was observed at scattered locations through the residential areas in Grants Pass to about RM 5.5, below the mouth of the Applegate River (RM 6.7-6.9 RR and RL), in the tailwater below Whitehorse (RM 7.6-7.8 RR), Finley Bend (RM 9.5-9.6 RL and RR), Griffin Park (RM 10.7-11.5 RL), below Highway Hole (RM 14.5 RR), the Robertson Bridge area (RM 14.7-15.0 RR), Hellgate Riffle (RM 18.8-19.2 RR), scattered areas between Dunn Riffle and Indian Mary Park (RM 19.7-21.2), and at various access location through to the Grave Creek ramp. During the 1992 field season most of the bank anglers observed were at Finley Bend, RL.

With respect to BS/C issues these users are most often only exposed to MTB wave run-up at the shoreline. These waves (0.5-1.33 ft. tall, Klingeman, Cordes, and Nam 1994) (see Figure 19) have been observed to cause anglers to quickly move across rocks and bedrock on the shore to avoid the waves and to make it necessary to move tackleboxes, etc. There are reports of unattended tackleboxes and other small equipment items being lost due to these waves. Accidents involving damaged equipment and injury due to these waves are possible, however, the wave patterns and wave heights should be easily predicted by bank anglers and these potential accidents can be easily avoided through minor adjustments in their activities.

b) Swimming and Wading; Swimming and wading in the study reach occur mainly at park access points. These include Schroeder County Park (RM 2.6 RL and RR), Griffin County Park (RM 11.4 RL), and Indian Mary County Park (RM 21.2 RL). Another location with concentrated wading/swimming activities is the Hellgate Bridge to the Stratton Creek Recreation Site (RM 20.5-20.8 RR) area. These activities were rarely observed at other locations in the study each. The safety risks of wading and swimming at SOCs in association with FC uses were addressed in the SOC Assessments and by SR/C modeling.

Although MTB wakes are highly prized by children wading and swimming, the Josephine County Parks Department places "No Wake" buoys at the 3 formal park swimming areas (Schroeder, Griffin, and Indian Mary). At each site a single buoy is typically placed at about the mid-point between the upstream and downstream extent of the swimming zone and near the middle of the channel. BS/C Study field observations showed that almost all MTBs came off-plane and slowed to "no-wake" speeds at these sites whether or not users were observed in the water or on the shore. Pvt-JB operators showed a tendency to come off-plane slightly less often when no users were observed. While most JB operators went to a "no-wake" mode at these sites, the single buoy marker resulted in a wide range in the off-plane and on-plane points. Some JBs were off-plane for several hundred yards while others were observed to be off-plane and at idling speeds for only several boat lengths. These ranges in no-wake operating mode were observed to be related mostly to the presence or absence of observed waders and/or swimmers. Most often the JB passed the wading/swimming areas to the outside of the marker buoy although there were a few passes observed when the JB passed between the buoy and the swimming/wading beaches.

No serious safety risk situations were observed during the BS/C Study field season, however, the variation in the length of "no-wake" operations and the side of the buoy on which the passes were made indicate that there could be some potential for safety risks during poor light and visibility conditions, particularly at dusk. If "No-Wake" buoys were placed at the upstream and downstream extremes of the swimming areas the extent of the "no-wake" mode could be more firmly established. If the buoys are set toward the side of the channel that has the water access, the JB operators would be more inclined to pass outside of the buoys.

The use of 2 buoys may tend to reduce JB operator flexibility in deciding the length of the channel through which to be off-plane. Presently JB operators have generally modified off-plane reaches in direct correspondence to the presence and area of activity of the waders/swimmers. The use of 2 buoys could induce unnecessarily long off-plane operations when no waders/swimmers are present or there are only a few occupying a small part of the recreation area, aggravating conflicts for the JB/MTB passengers. The 2 buoys may also "formalized" the wading/swimming area and tend to limit the off-plane area to the reach between buoys even if wading/swimming activities extend beyond the buoys. This could increase safety risks and conflicts to waders and swimmers and induce additional aggravation between motorized and wading/swimming activity types.

There has been some concern that the swimming area at Indian Mary Park is so close to the top of the downstream riffle that the MTBs need to be on-plane through at least part of the swimming area to safety navigate Indian Riffle. The review of water depths at this location indicted that at both the low and high flow conditions the location of the set-down threshold should allow a downstream operating MTB to pass the swimming area before going on-step to achieve on-plane operations prior to passing the set-down threshold. For upstream MTBs, the approach to the set-down threshold at the head of the riffle can be made at reduced on-plane speeds allowing a full set-down to "no-wake" mode at the downstream end of the swimming area.

At this location a high speed stop during upstream MTB operations could generate a wave train that could pose a safety risk to swimmers. If swimmers should be swept through the head of the riffle they are most likely to be drifted along the RL bank. The RL channel margin of Indian Riffle is deep, swift, and turbulent and the bank is an undercutting a low vegetated terrace. The bank can have various portions of trees extending into the channel and can cause strainers that may entrap floaters and swimmers. Along with a two marker buoy approach (as above), potential safety risks could be further guarded against if the downstream buoy was connected to the RL shore with a floating rope and multiple floats that would define the downstream end of the swimming area and provide an additional opportunity for children to avoid being inadvertently drifted into Indian Riffle.

9) MTB Resource Conflict Issues:

During the BS/C Study field season several resource conflict issues were identified that could be expected to reduce FC user tolerance of MTB operations and could lead to induced BS/C issues at SOCs and in non-SOC portion of the study reach. While not directly inducing SR/C concerns these are issues that degrade resource values, lead to antagonism, and ultimately relate to poor on-river communication and possibly BS/C problems induced by FC behavior patterns.

a) MTB Intercoms*; The configuration and uses of on-board intercoms leads to the unnecessary projection of operator communications across water surface areas. Intercoms mounted on windshields and pilot towers were observed by WRC staff to project intelligible audio for over a quarter of a mile of open water even while the MTB is operating on-plane at high speeds. This increment of tour-related noise is unnecessary and can often add additional annoyance to other on-river and riparian users. This can, in part, lead to confrontational conflicts.

It is feasible to modify the configuration and use of passenger intercom systems such that the level of unnecessary noise is reduced and unnecessary resource conflict avoided. The intercom speakers could be moved to positions under the seats (or other suitable locations below the gunnels) and could be operated at low enough decibel levels to ensure that long distance projection does not occur. The intercom system could be operated at low power and used only when the MTB is off-plane to ensure that high decibel levels are not needed. At times it could be convenient for MTBs to have an intercom system to communicate with FC and other river users. This could be accommodated with a separate intercom system, with one speaker mounted above the gunwales. At present the need for the second intercom system is so limited that two systems should not be necessary.

b) MTB Paint Schemes*; The MTBs on the study reach have two base colors; blue and orange. The company name is displayed prominently on both sides in letters that can be read from several hundred yards. Since there is only one MTB owner/operator on the study reach on-river advertising has little real marketing value. There are also boat names on the sides and stern and "MRP" numbers on both sides of the bow. The "MRP" numbers are the Medford Recreation Permit numbers issued to all commercial operators on the study reach by the BLM. This lettering and numbering creates a confusion of information to other on-river users. This results in two safety risk related outcomes. First, all the lettering, etc. detracts from the FC users attention on the lead boat craft number "flag". This problem is usually aggravated by MTB operator behavior patterns that include attempts at creating amicable relations between non-motorized recreationists and MTB passengers by inducing wave cycles and/or conversations. Second, the melange of large and small lettering and enumeration on the MTB hulls makes it very difficult for FC and other non-motorized users to identify a particular MTB craft when safety risk or conflict incidents occur. The boat names, the only craft-specific identifier, are usually too small to read at any substantial distance, particularly when only the stern is visible and the MTB is traveling away from these users at on-plane speeds.

MTB craft paint schemes can be designed to improve the ability of on-river users to observe the craft number flag and to identify specific MTB craft. This would include reducing the size of the company name on the sides, and reducing the size of the boat name on the sides and eliminating the boat name on the stern. To assist in craft identification, relatively large individual boat numbers or letter designations could be painted on the forward third point of the MTB sides and on the stern.

C: Gold Hill Study Reach

The BS/C Study scope was primarily directed at the BS/C concerns on the Hellgate Study Reach and most of the 1992 field work was conducted in that area. As a result only about 12 field and sample days were invested on the BS/C issues on the Gold Hill Study Reach. This level of site review did not allow for the development of a data base complete enough nor large enough to undertake the full probabilistic BS/C risk model methods developed in this BS/C Study.

The primary data elements that were deficient and prevented the appropriate application of the full BS/C risk modeling included: 1) study reach FC use pattern information that prevented the development of a FC Use Distribution Model (seasonal use levels, daily use levels, day-type factors, UUCs shapes, etc.); and, 2) FC use patterns in the SOCs (float route distribution and float speeds, etc.). Reliable information on both of these FC use patterns is required to conduct the full BS/C risk modeling assessment. Given the very low FC use levels observed in the 1992 study period, a relative large number of sample days at each SOC would be required to collect a statistically sound representation of FC float patterns. In addition to more complete FC use information, MTB stop tests should be conducted to establish PSDs and SSDs (See Chapter IV, B, 6) and 8)). As a result of these limitations a FC Use Distribution Model was not developed for this study reach, the SOC Assessments used limited field measurements of FC uses in the Gold Hill Study Reach SOCs and used assumed FC float speeds from the larger Hellgate Study Reach SOC data base, and the SR/C Model was not used to develop estimates of MRS safety risks.

This review of the BS/C concerns on the Gold Hill Study Reach was based on a general SOC Assessment approach, on-river observations, limited contacts with angler and FC users, and on discussions with the MTB owner/operators and the Jackson County Marine Deputy. Given that the on-river field and sample days were very limited there could be some BS/C issues that were not identified during the investigation.

1) Streamflow Magnitudes and Safety Risks:

Similar to the Hellgate Study Reach, safety risk potential varies with flow level on the Gold Hill Study Reach. Lower flow conditions create shallower MTB operating conditions in SOCs, exposed more rocks in the SOCs creating narrower navigational limits, and in some SOCs, portions that can be drifted by MTBs under higher flow conditions must be navigated on-plane at lower flows. The MTB owner/operator (Cort, pers. comm.) and the Jackson County Marine Deputy (Oachs, pers. comm.) stated that lower flow conditions imparted greater MTB/FC encounter safety risk potential because of reduced MTB navigational options.

As with the Hellgate Study Reach, for the SOC Assessment approach these two safety risk-related flow conditions were functionally defined as the physical channel hydraulic conditions that are typical of: 1) higher flows that characteristically occur during the MRS when MTB options are optimal and safety risks are minimal; and 2) lower flows that occasionally occur in the MRS in which MTBs are still operating but safety risks are higher due to more restricted MTB options. The low flow conditions would not apply when flows are too low for MTB navigation.

During the BS/C Study 1992 field season, streamflows in the Gold Hill Study Reach ranged from about 1000 cfs to about 2300 cfs as reported by the Rogue River USGS "Raygold" gage about 5.4 miles upstream of the study reach. Through the field review period, flow conditions were predominantly in two ranges; between 1000 and 1100 cfs from July 10 through August 10 and between 2000 and 2300 cfs from August 14 to September 10. From July 1 to July 10 flows steadily declined from 1600 to 1100 cfs, increased from 1000 to 2270 cfs between August 11 and 14, and declined from 2000 to 1200 cfs between September 10 and 30. Although along the 9.6 mile study reach there are about 130 square miles of ungaged watershed contributing flows to the study reach, the Raygold gage information was considered adequate in representing flows throughout the study reach during the MRS. This was based on the general aridity of these watersheds during summer months.

Both the MTB owner/operator and the Jackson County Marine Deputy stated that low flow channel hydraulic conditions were present during the periods in which flows were 1000-1100 cfs and that high flow conditions were present during the period that flow were in the 2000-2300 cfs range. Based on these user observations and WRC field observations of MTB activities during the 1992 MRS, it is our tentative conclusion that low flow conditions range between an unknown flow below, but probably not far below 1000 cfs to about 1500 cfs, and high flow conditions range between about 1500 and 2300 cfs.

As presented elsewhere insufficient field and sample days were available in the Rogue River BS/C Study to develop an adequate data base of the user and use patterns on the Gold Hill Study Reach to reliably complete the SOC Assessments and SR/C Model application methods developed in this study. In this regard only the SOC Assessment Plates in Appendix J, and the discussion of SOC hazards in the following section are used to address low and high flow condition safety risk differentiation; the SR/C Model was not used and MRS MOs were not calculated.

In the future should it be desirous to fully model BS/C concerns using the probability methods developed in this study, a greater field and survey effort over a more complete flow range than was available during the 1992 field season could serve to more accurately establish appropriate threshold ranges for the flow dependent channel/hydraulic conditions.

2) SOC Hazards:

Following the development of the SOC Assessment methods and the various assessment procedures only three of the initial SOCs were found to have MTB operational limitations that could result in inadvertent safety risks as defined in this BS/C Study. These are "First Drop", Gold Hill Riffle, and Twin Bridges Riffle. Based on field observations, assumed set-down thresholds, and MTB SSDs at the other potential SOCs for all scenarios there were MTB operational options and LOS thresholds that eliminated the possibility for inadvertent accident situations developing.

Because the probability based SOC Assessment and SR/C modeling were not used, the safety risk aspects of these SOCs are presented here in qualitative terms. Often FC float speeds are assumed values based on the hydraulic conditions of specific portions of the SOCs and observed FC float speeds in similar channel hydraulic conditions on the Hellgate Study Reach. Assumed MTB speeds are based on observations on the Gold Hill Study Reach and on statements made by the MTB owner/operator on this study reach. FC route splits used were based on the limited Gold Hill Study Reach field work because the channel configurations observed supported the assumption that the FC use patterns could be reasonably representational of a long term average.

a) MTB - SOC Probability of Risk; For the "First Drop" downstream MTB operational scenarios only a small measure of potential safety risk exists under low flow conditions for the very slow FC positioned over a very small portion of the SOC (See Plates 67 and 68, ans Chapter IV). This safety risk involves overtaking FC in turbulent tailwater areas. Figure 53 is a photograph along the downstream MTB route from the RIP area showing that the RR side of the SOC below the drop is unseen. The position of the MTB in this photograph is considerably RL of the route that was observed to be used by pvt-JBs. The farther RR the JB route the more restricted the LOS and the greater the potential for a MO. For upstream MTB operations potential safety risks are present under both flow conditions and involve passing FC while on-plane at the top of the SOC which could throw small rafts or induce FC/swimmers to float along the extreme RR bank that could lead to entrapment in tree strainers (See Plate 69). Figures 51 and 52 are looking upstream and show that the RR side of the channel above the drop is unseen until the MTB has completely passed the top of the drop. Downstream operational risks can be reduced or eliminated by additional MTB wait times even when no FC are observed but upstream safety risks are not avoidable.

The Gold Hill Riffle SOC has a long and complex channel. For downstream MTB operations under both low and high flow conditions the potential safety risks involve two situations in which FC could be overtaken by a MTB in tailwater areas and one that involves pop-outs where FC can suddenly enter the MTB route at the bottom of the island (See Plates 70 and 71). Because of additional drifting options available at higher flow conditions the safety risks associated with overtaking FC in the tailwater are greater at low flows. The pop-out risks are the same at both flow conditions. Figure 54 shows a downstream operating MTB just above RIP3 (See Plate 70). Both upstream and downstream operating JBs use the route along the RR side of the RL channel. This alignment maximizes potential JB accidents and reduces

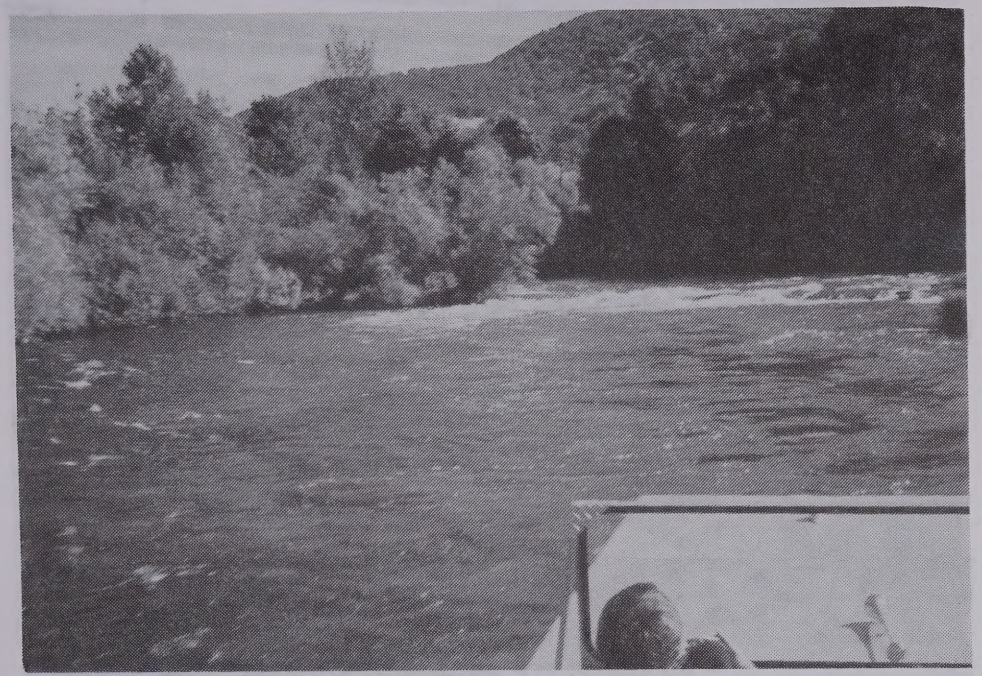


Figure 51

"FIRST DROP"

View from an upstream operating "Small" sized MTB located about 125 ft. downstream of the RIP at Point E, Plate 69. From this location the view above the SOC is slightly better than along LOS F from the RIP. The low overhanging tree limbs along the RR bank below the main drop can be seen in the left side of the photo.

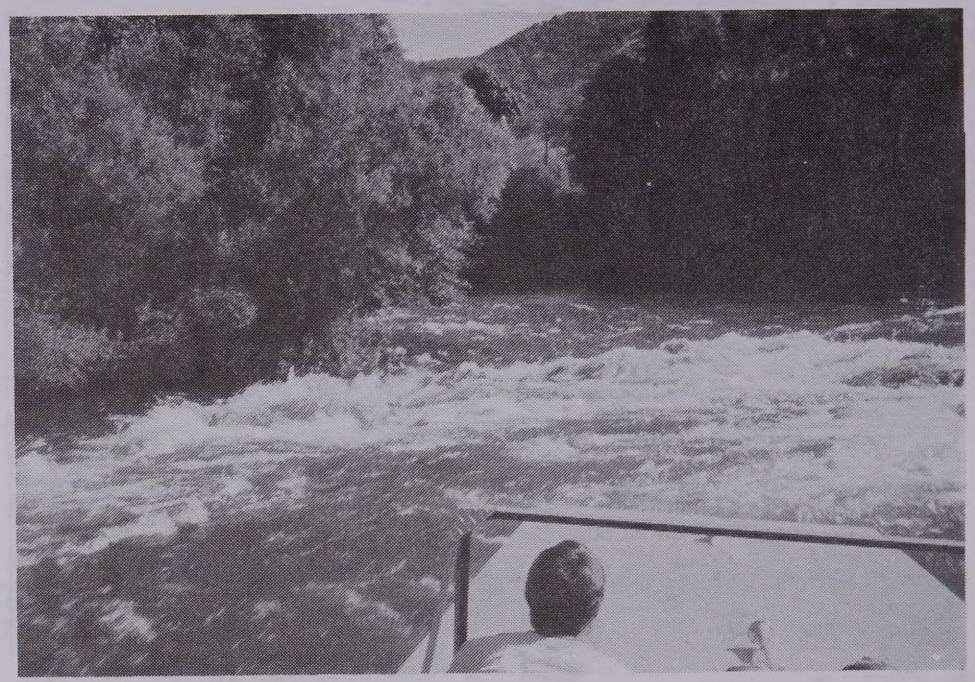


Figure 52

"FIRST DROP"

View from an upstream operating "Small" sized MTB located just past the RIP at Point E, Plate 69. From this location the view above the SOC is slightly better than along LOS F from the RIP. The MTB route is straight up the drop on a line slightly to the right of the hull axis in this photo. Unseen FC floating along the RR side of the channel above the drop can enter the rapid from behind the tree canopy and enter the main drop during the MTB run. The potential MTB/FC encounter would be in swift turbulent water and the craft would be close enough to result in a MO situation.

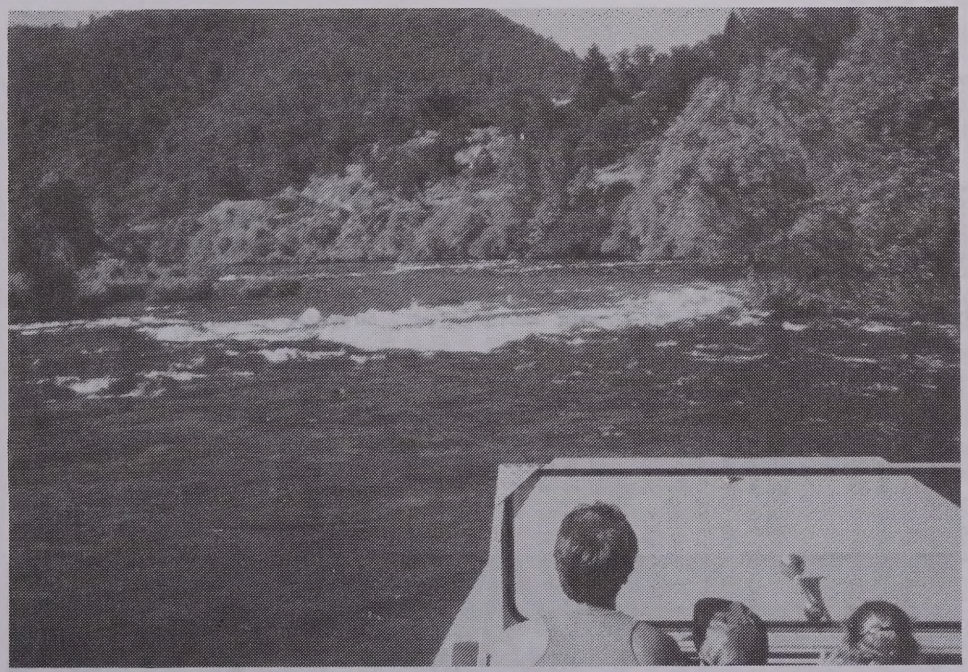


Figure 53

"FIRST DROP"

View from a downstream on-plane operating "Small" sized MTB located just before Point D, Plate 68. From this location the view to the bottom of the SOC is slightly better than along LOS C from the RIP. The MTB route is diagonally RL across the tongue and tailwater slightly to the left of the hull axis in this photo. Unseen FC could be in the tailwater but the MTB has time to reach a safe stopping location in the flat but swift water RL below the main drop (Point F, Plate 68) without creating a MO.

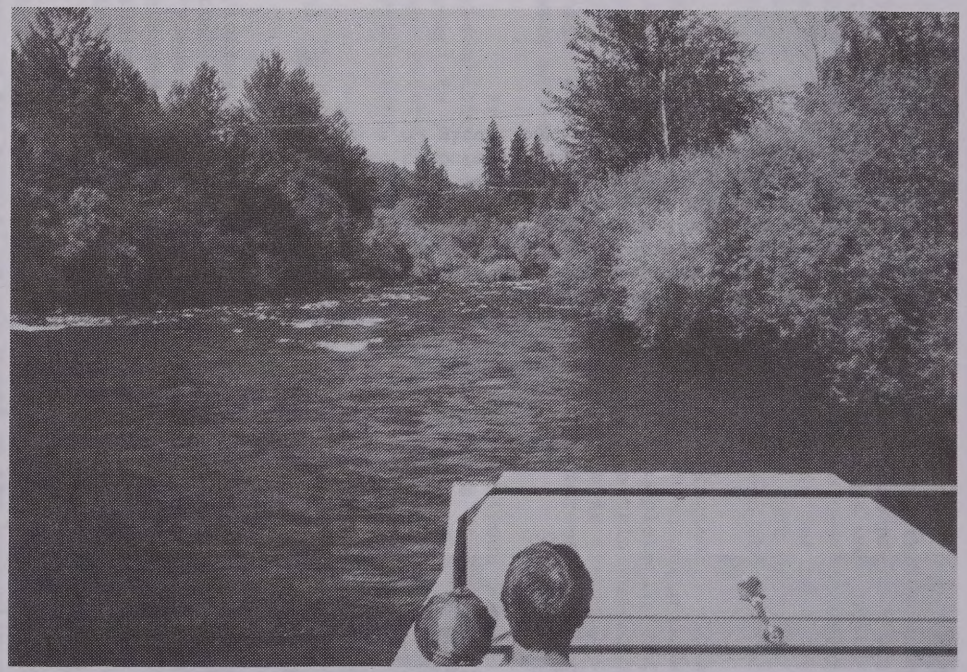


Figure 54

GOLD HILL RIFFLE

View from a downstream on-plane operating "Small" sized MTB located between Points M and K, Plate 70. From this location the view downstream is approximately along LOS O. The MTB operator can not see the lower rapid and tailwater areas nor the pop-out location at Point P (Plate 70). The MTB route is along the RR side of the channel next to the island. This is the same route as taken by upstream running JBs which is an additional safety risk issue.

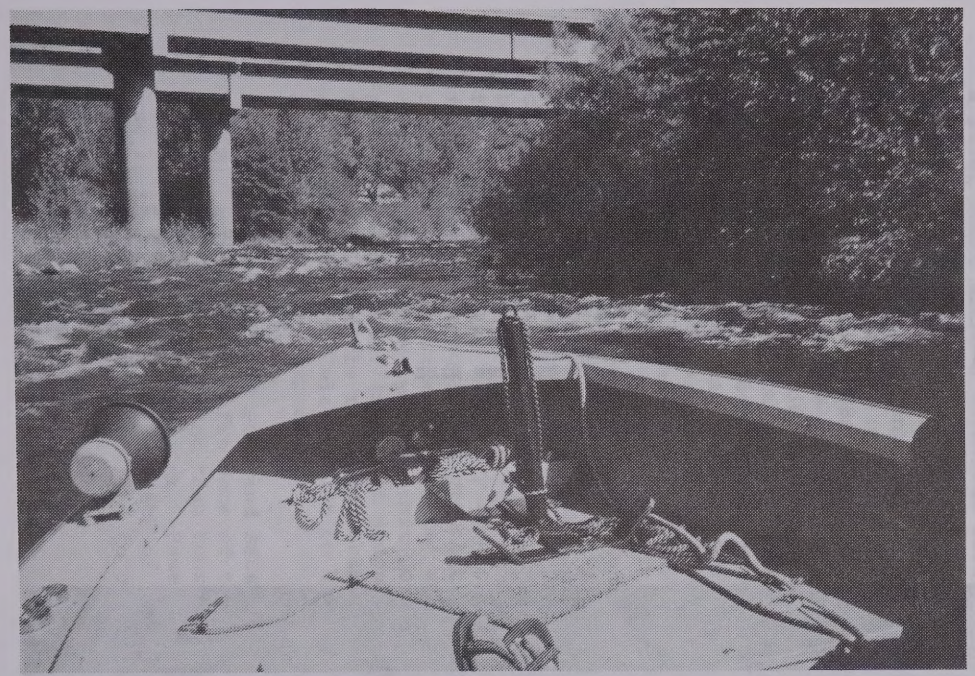


Figure 55

TWIN BRIDGES

View from an upstream on-plane operating JB (Sheriff's patrol boat) just past RIP1 at Point D, Plate 74. View into the SOC is along LOS E. The JB operator can see the set-down area next to the island at Point H, Plate 74, but can not see the ST area. After run initiation, the JB has enough time to reach Point H before any FC that may come into view at the LOS E threshold. This set-down area has an isolated eddy that allows floating FC to pass stopped JBs without creating a MO situation. From the set-down area at Point H, the JB operator can see to the ST area (See Figure 56).

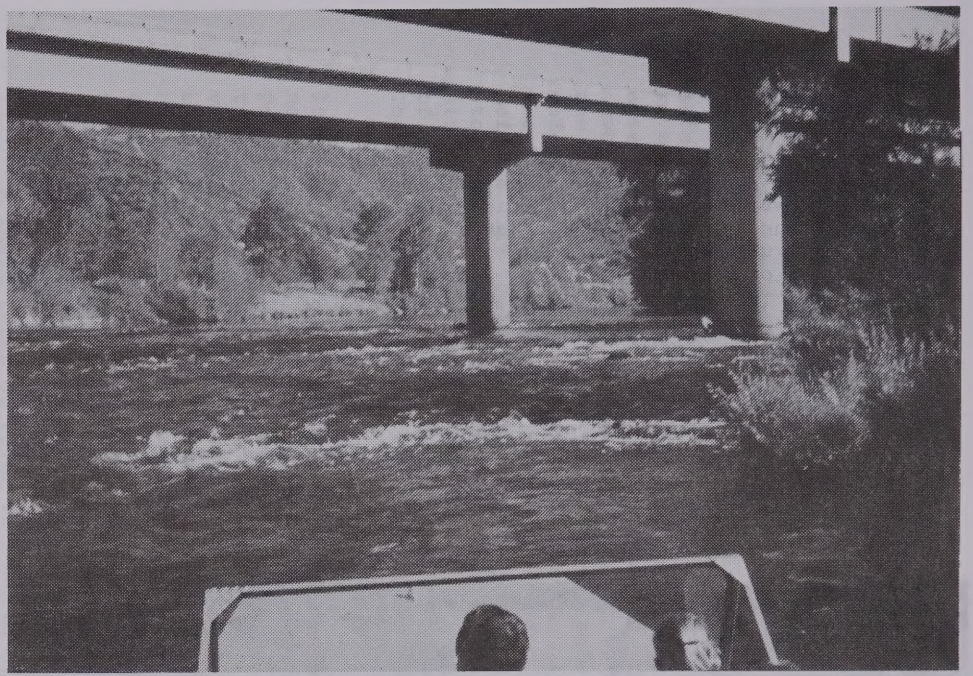


Figure 56

TWIN BRIDGES

View from an upstream off-plane operating "Small" sized MTB at about ST1, Point H, Plate 74. View to the top of the SOC is along LOS I. The MTB operator can see the set-down area at the top of the SOC (flat water upstream and to the photo right of the upstream most bridge piling. MTBs can wait in this eddy until the route to ST2 is clear of FC. The foreground shows that in-floating FC would pass to the RR of stopped JBs and MOs would be avoided.

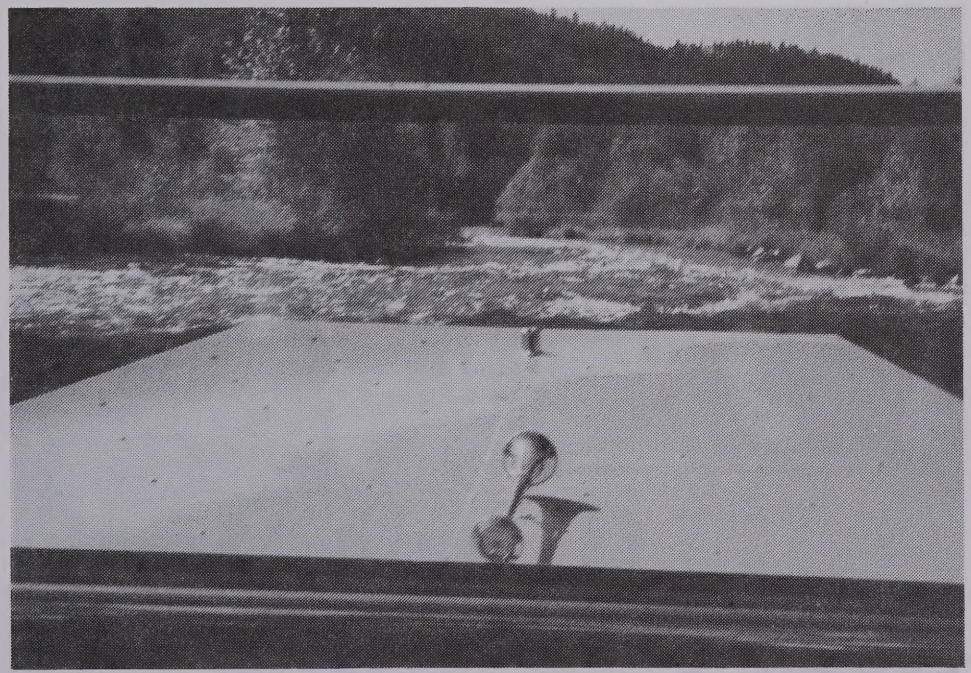


Figure 57

TWIN BRIDGES

View from an downstream on-plane operating "Small" sized MTB located just upstream of the upstream most bridge crossing, Plate 73. View into the SOC is better than along LOS D, Plate 73, with the riffle drop at the bottom of the island visible and ST2 just out of sight. From this location, should FC be observed ahead, the MTB can drift from about Point F, Plate 73, and arrive at ST2 after any but the very slowest FC float that may be observed.

Figure 58

GLARE

Photograph indicating the additional safety risk potential induced by glare on the Gold Hill Study Reach. Glare was observed to be most important when the sun was less than about 45 degrees high and within about 15 degrees of the line of sight. On the Gold Hill Study Reach glare was noted as an additional potential safety risks issue on the upstream leg of AM MTB trips, particularly at Gold Hill Riffle (shown in this photo) and the downstream leg of the Dinner trip before the dinner stop.

visibility to the tailwater area of the SOC. Upstream operational safety risks involve FC floating into the into areas of limited MTB operational situations during the MTB run from the RIP to the ST induced by LOS limitations (See Plate 72). Downstream operational risks can be reduced or eliminated by additional MTB wait times even when no FC are observed but the waits would need to be up to 6 minutes long to eliminate the safety risk potential. Upstream safety risks are not avoidable.

At the Twin Bridges SOC for downstream operational direction, potential safety risks are the same for both flow conditions and involve MTBs overtaking slow FC at the bottom of the SOC while off-plane and drifting (See Plate 73). The assessment undertaken indicates that only the slowest 10-15% of the FC could be involved and that the area of potential MO is very small. An additional MTB wait at the top of the SOC could eliminate the safety risks. For upstream operations the safety risks for both flow conditions involve unseen FC above the island at the time the MTB run is initiated (See Plate 74 and Figure 55). However, because of the well defined eddy/tailwater situation adjacent to the island, MTBs can come off-plane and stop out of the main current and allow FC float-bys to occur that are not MO situations. From that location MTB operators can see through to the ST at the top of the SOC before committing to run the last portion of the SOC (See Figure 56). Therefore upstream operations have no inadvertent safety risk potential.

The fundamental result of the SOC Assessments is that at the SOCs with some level of MO safety risk, using the best skills and most prudent judgement, MTBs can not be operated in such a way as to avoid involvement in incidents that have the potential to lead to accidents. In accordance with the basic SOC Assessment fault-tree risk approach assumptions developed in this BS/C Study the MTB operator uses view fields, knowledge fields, and best and most prudent judgement to determine MTB operations in SOCs, and uses best operator skills and MTB craft operating characteristics to prevent MTB/FC encounters in SOCs from evolving into MO conditions. Once MTB runs are initiated into these SOCs, MOs can occur as a function of user levels and the random timing of activities in the SOCs. Based on the present level of information, in each of these SOCs with each lead MTB run, it is merely a chance probability that MTB/FC MO encounters will occur.

A basic tenet of river recreation boating safety is that when no safe stopping point is within the field of view it is unsafe to proceed into sections of a river where unknown hazardous circumstances may exist. This provides river boaters with a margin of safety that allows them to avoid having to proceed into potentially hazardous sections where the ability to safely abort the run may not exist. The SOC Assessments of the Gold Hill Study Reach SOCs indicate that within the resolution capacity of the fault-tree risk assessment approach and the data presently available, MTBs do not have that margin of safety in some situations. The margin referred to here is that which allows operators to avoid inadvertently creating potential accident situations, not necessarily the margins of safety needed to avoid accidents once the accident situation has occurred. By definition a MO is an inadvertent (when best MTB operator skill and judgement is applied) MTB/FC encounter in a SOC that results in less than adopted safe craft separation threshold distances. Therefore each MO incident is an unavoidable incident that can, but not necessarily will, lead to an accident.

Because the channel conditions of the SOC/scenarios provide the opportunity for MTB operators to inadvertently place MTBs in MO situations and because the accident outcome of MOs are circumstantial and problematical, each MO situation is characterized here as an "unsafe" situation. By contrast, a "safe" situation would be characterized by channel conditions that allow MTB operators to proceed throughout the trip itinerary from one safe stopping location to the next with view fields that are adequate to prohibit "inadvertent" commitments to situations that could evolve to accidents. "Safe" conditions are those that eliminate the "inadvertent" parameter and limit potential accidents to those that may result from poor operator skill, imprudent judgement, human error, and equipment failure, etc. These are the factors that are potential accident parameters in all river recreation settings. For more elaboration on the issue of "safe/unsafe" conditions see section B: 2) a), of this chapter.

The assumed MTB PSDs and SSDs for "Small" sized MTBs (See Chapter IV, B: 6) and 8)) appear to just fit some of the set-down areas in some of the SOCs. If SSDs are really somewhat longer than those assumed, the probabilities for inadvertent safety risks would be greater. Based on the present information on MTB PSDs, the use in the Gold Hill Study Reach of "Medium" sized MTBs of the type used on the Hellgate Study Reach would lead to greater safety risks. Also because of increased

operational speeds and size (length, width, capacity), and the general channel size, the use of "Medium" sized MTBs would most likely lead to increased levels of resource conflict with other users. During the 1992 field season the 30 ft. "Miss Rogue River" was not in use so we can not provide observations on the suitability of this craft on the Gold Hill Study Reach. If a complete SOC Assessment and SR/C Model is to be applied in the future to estimate MOs on this study reach, stop tests on the MTBs in use should be undertaken to establish PSDs and SSDs.

b) Pvt-JB - SOC Probability of Risk; The pvt-JBs in use on the Gold Hill Study Reach are similar to those on the Hellgate Study Reach. Refer to section B: 2) b) in this chapter for a general discussion of pvt-JB issues. As with the use of pvt-JBs on the Hellgate Study Reach the MTBs and pvt-JBs on the Gold Hill Study Reach led to different levels of safety risk potential in three SOCs. Because the MTBs of the Gold Hill Study Reach are considerably small and slower than those of the Hellgate Study Reach and the pvt-JBs are roughly the same, the differences between these JB types on the Gold Hill Study Reach are not as great.

The PSD to fully stop for the "Small" sized MTB operating on the Gold Hill Study Reach is assumed to be 3 boat lengths or about 75 ft. As with the Hellgate Study Reach, observations of pvt-JBs indicate that PSDs can be very short and, because of the permissibility of turning stops, SSDs can be as short as 40-60 ft. for these craft. This indicates that many of the potential safety risks for downstream operating MTBs noted at the SOCs could be somewhat reduced for pvt-JBs. Upstream safety risks however would remain the same.

Several observed pvt-JB operational elements led to the conclusion that there are circumstances in which pvt-JBs present greater potential safety risks than do MTBs. Particularly at Gold Hill Riffle and somewhat at "First Drop", pvt-JB operators were observed to cut corners more tightly than did MTBs, and they were observed to engage in less safety risk prevention activities. At Twin Bridges during upstream operations, pvt-JBs were not observed to operate so as to enhance the approach visibility by following the MTB route through point A on Plate 74. This operational pattern increases the probability that FC in the SOC above LOS D past the RR side of the island are unseen. In this situation however, it is possible for pvt-JBs to reach the eddy at the island before FC travel from above LOS D to the eddy. In this situation MOs are still avoided, however, without the additional approach visibility there is a greater likelihood for MTB/FC encounters in the SOC.

At Gold Hill Riffle pvt-JBs in both operational directions tend to pass very close to the island between points M and P on Plate 70 and during downstream operations were not observed to take any precautionary pauses or engage in any effort to swing to the RL to enhance downstream visibility in the set-down area of point M on either Plates 70 and 71. These observed use patterns would result in greater safety risks than result from MTBs that often, but not consistently, operate to increase visibilities at this point (See Figure 54). This is also the case at the top of Gold Hill Riffle where MTBs travel the route through point C on Plates 70 and 71 to enhance visibility into the SOC whereas most pvt-JBs were observed to use the alternative route more to RR. This RR route leads to decreased visibility and greater potential for overtaking FC before they reach an ST. This RR route is also used by pvt-JBs during upstream operations. In this situation this leads to greater potential safety risks of JB/FC encounters at less then minimum MO craft separation distance along the shoreline. Many FC follow the shoreline route because many FC launch at the beach RR about 300 ft. above point A.

At "First Drop" pvt-JBs and MTBs differ during upstream operations in a similar manner. On Plate 69 many pvt-JBs were observed to follow the FC route along the RR shoreline once they clear the rapid tongue at about point H. Similar to the top of Gold Hill Riffle, the access ramp at Gold Hill Regional Park is located RR about 1600 ft. upstream of "First Drop" and most of the FC follow the route along the RR shoreline into the rapid.

The general conclusion from limited field work and abbreviated SOC Assessment work is that while pvt-JBs have shorter PSDs and SSDs than do the MTBs, and as a result could have reduced safety risk potential in SOCs, their normal operational approaches to the SOCs result in greater safety risk potential. Potential safety risks associated with pvt-JBs could be reduced by adopting the MTB operational approaches to running the SOCs and improved further by adding supplemental wait times during downstream operations as presented in the narratives of the SOCs in the foregoing section.

3) MTB Itinerary Schedule Issues:

MTB operations on the Gold Hill Study Reach includes 4 daily trip itinerary schedules; a Noon 1-hour trip, a PM 1-hour trip, an AM 2-hour trip, and a Dinner trip. Each of these trips depart from the City of Rogue River, from the Coyote Evans Park area (RM 9.6), proceed upstream and returns to the City of Rogue River. The relative degree of potential safety risks at the SOCs involves the relationship of the number of FC that a lead MTB is likely to encounter at the SOCs during the trip. The number of FC likely to be encountered is a function of the MTB trip itinerary schedules and the FC daily use pattern throughout the study reach.

As mentioned earlier, limited available field and sample on the Gold Hill Study Reach prevented the development of a fully functional FC Use Distribution Model as was developed for the Hellgate Study Reach. On-river observations and conversations with users did allow for the informal separation of the study reach into 4 sections with varying FC use levels and time of day patterns. Because of very light FC use levels, the probability of encountering FC in the SOCs of these sections is presently a highly random function. Greater FC use levels would lead to a more consistent daily pattern and make the probabilities of SOC occupation more reliable. These sections are as follows:

Section 1; Powerhouse Return (RM 0.0) to Gold Hill Regional Park ramp (RM 0.2). This section is only used by those FC that are finishing the Class III/IV run from Gold Ray Dam to the take-out at Gold Hill Regional Park. FC are typically oar rafts with 2-5 users. Uses are typically in the mid-day to late afternoon period. Of the total daily FC using the Gold Hill Study Reach, an estimated 5% would be found on this section.

Section 2; Gold Hill Regional Park ramp (RM 0.2) to Gold Hill beach (RM 0.8). This section is used by those FC that put-in at the Gold Hill Regional Park ramp and float through to either the Valley of the Rogue State Park or the Coyote Evans Park access points. Many small inflatables and driftboats are in this section. Uses on this section are associated with the start of a relatively long float (6.5 to 9.4 miles) and are typically present in the mid to late morning through to mid-afternoon. Of the total daily FC using the Gold Hill Study Reach, an estimated 30-40% would be found on this section.

Section 3; Gold Hill beach (RM 0.8) to Valley of the Rogue State Park ramp (RM 6.7). This section is used by those FC that put-in at the Gold Hill Regional Park ramp or the Gold Hill beach and float through to either the Valley of the Rogue State Park or the Coyote Evans Park access points. Many small inflatables and driftboats are in this section. Uses on this section are associated with the main part of a relatively long float (5.9 to 9.6 miles) and are typically present mid-morning through to late-afternoon and evening with a defuse peak in use starting at about noon at Gold Hill and progressing downstream over about 2 hours. Of the total daily FC using the Gold Hill Study Reach, an estimated 90-95% would be found on this section.

Section 4; Valley of the Rogue State Park ramp (RM 6.7) to Coyote Evans Park ramp (RM 9.6). This section is used by those FC that are on longer trips (8.8 to 9.4 miles) continuing on past the Valley of the Rogue State Park from upstream put-ins and a small number of put-ins at the Valley of the Rogue State Park ramp. The main FC uses on this section are the continuing FC and driftboat trips and, since they are in this section at the end of the trip, uses occur more frequently in the afternoon and, when driftboats are in use, often in the evening. The local FC put-ins can occur throughout the day but this involves only a very limited number of FC. Of the total daily FC using the Gold Hill Study Reach, an estimated 10-20% would be found on this section.

The 1-hour MTB trip itinerary includes operating 6.1 miles upstream to Rock Point (RM 3.5), in 30 minutes and returning in 30 minutes. In the MRS the 1-hour trip itineraries have two schedules; a noon schedule of 1200-1300 hours and a PM schedule of 1400-1500 hours. The 2-hour trip itinerary includes an arrival at Rock Point in 30 minutes, proceeding to the Powerhouse Return (RM 0.0) in another 30 minutes, and returning to the City of Rogue River in 60 minutes. During the MRS the 2-hour trip itinerary schedule is a departure at 0900 and a return at 1100 hours. The Dinner trip itinerary includes operating upstream to the Powerhouse Return (RM 0.0) in 60 minutes, returning to a riverside restaurant at about RM 6.1 RL in another 30 to 40 minutes, a 1.5 to 2 hour dinner stop, and a 30 minute downstream run back to the City of Rogue River. During the MRS the Dinner trip itinerary schedule is a departure at 1630, a turn around at Powerhouse Return at 1730, a dinner stop between 1800 and 2000, and a return at about 2030.

With respect to potential safety risks at SOCs associated with MTB/FC encounters, the MTB trip itinerary schedules are fairly well positioned to avoid much of the FC float traffic. The 2-hour MTB trip is scheduled to run from 0900 to 1100 hours through all the SOCs. This time of day is generally earlier than the FC uses in the 6.5 miles of the study reach between Gold Hill Regional Park and Valley of the Rogue State Park. During anadromous fish runs, early morning driftboat activity could be encountered by this MTB trip particularly between Rock Point and Gold Hill Regional Park. During the lower flow portions of the 1992 MRS the MTB owner/operator voluntarily reduced the itinerary of the 2-hour trip to that of a 1-hour itinerary on weekends when high FC use levels were expected. This itinerary schedule modification could lead to substantial reductions in inadvertent safety risks should a significant number of FC run relatively early trips.

Generally the noon 1-hour MTB trip (1200-1300 hours) is early enough in the recreation day that few FC would be encountered along its itinerary except for early FC trips that may be encountered in the upstream portion of the MTB trip itinerary. The PM 1-hour trip (1400-1500 hours) is positioned such that it coincides at Twin Bridges, in both operational directions with the mid-afternoon peak FC uses but it does not run through either Gold Hill Riffle or "First Drop". The Dinner trip in late enough in the recreation day that during the upstream leg (1630 to 1730 hours) FC on more typical trips could be encountered up to about Rock Point. For unusually late starting FC trips, FC could be encountered through to the Gold Hill Regional Park ramp and on the downstream leg to the restaurant. This late in the day (about 1730) relatively few FC trips are running the SOCs near the top of the study reach. On the Dinner trip the 2030 return to the City of Rogue River is late enough that backlighting from the western horizon can make discerning swimmers in the water very difficult.

Based on the MTB trip itinerary schedules, FC use patterns and the potential safety risks at SOCs, little safety risk exposure reduction would be realized by modifying the MTB trips. This is particularly true if the 2-hour trip continues to be reduced to a 1-hour trip itinerary during heavy use weekend days and recommended safety risk reduction SOC operational approaches are used (See above section). If only the Dinner trip proceeds above Rock Point only that trip would incur unavoidable inadvertent safety risks even when precautionary SOC operational approaches are used. These unavoidable safety risks include upstream operations at Gold Hill Riffle and "First Drop" while downstream inadvertent safety risks could be reduced or eliminated with controlled MTB waits at the appropriate RIPs.

4) MTB Craft and Convoy Management:

On the Gold Hill Study Reach the typical MTB trips are fairly short, lasting 1-2 hours on the water for 12.2 or 19.2 mile round trips, and involve typically 1 MTB and occasionally 2 MTB craft on a trip. Because of the trip milage and time factors, the MTB trips on the Gold Hill Study Reach are less pressed for time at SOCs and appear to be less inclined to incur Overt MOs due to entering SOCs at less than optimal safety margins, etc., than MTB trips on the Hellgate Study Reach. In addition no instances were observed in which Overt MOs were induced in non-SOC areas by MTB operator decisions.

With the exception of MTB wait times and SOC run speeds no unusual MTB craft or convoy management problems or issues were identified. The SOC Assessments undertaken in Chapter IV indicate that at each of the SOCs variable increments of additional MTB run time could reduce the probabilities of safety risks. Longer run times could be realized by MTBs stopping and waiting at specific RIPs even though FC are not observed in the SOCs or by running at reduced speeds. Additional wait times would result in safer MTB operations but would also induce conflicts on MTB passengers regardless of the presence of FC. The narratives on Plates 67 through 73 address the recommended locations and durations of additional MTB waits and the degree of relative safety risk reduction. Issues such as convoy size and management, passenger comfort, and MTB scheduling were not identified as potential problems under present MTB and FC uses. As a result, no MTB craft or convoy management safety risk problems were observed and no recommendations to modify these aspects were developed.

5) Recreation Management:

The Gold Hill Study Reach is outside the Rogue Wild and Scenic River management area and is therefore outside the area of BLM's recreation management responsibility. It is also above the point on the Rogue River that is considered the head of navigation (RM 101 at the 6th Street Bridge in Grants Pass) and is therefore outside the jurisdictional area

of the USCG. As a result the potential BS/C issues concerning MTBs and other recreational activities on the Gold Hill Study Reach are solely under the jurisdiction of the State of Oregon through the Oregon State Marine Board (OSMB) and the enforcement authority of the Jackson County Sheriff's Office and Marine Deputy. For details on the boating safety authority and enforcement aspects of the OSMB see section B: 7) b) of this chapter. No agency has assumed general recreation management responsibilities for the Gold Hill Study Reach.

Although the limited SOC Assessment approach used on the SOCs of the Gold Hill Study Reach showed that inadvertent MO situations exist, the FC use levels are presently so low that if additional safety prudence at these SOCs (as suggested above) were exercised, a full SR/C Model application would probably result in very few MRS MOs. As stated in section B: 2) of this chapter any MO situation, regardless of probability, can be considered as an "unsafe" situation in that MTB operators can not operate between safe stopping locations without traveling through unseen portions of the SOCs. For a variety of reasons (see section B: 2 for details) MTB operators may not be fully aware of LOS limitation nor their potential significance to MO situations. The level of MO situation awareness on the part of MTB operators could be enhanced if at the start of each season the Jackson County Marine Deputies and the MTB operators conducted field checks of operational LOSs, confirmed safe stopping locations for both operational directions, and confirmed those portions of SOCs within which FC could be at risk under normal MTB operations.

More active engagement with the MTB operations would be useful particularly with regard to PSDs and SSDs. With adequate MTB stop tests and fully adequate SOC Assessments, the OSMB could assess the SOCs of the study reach to determine an appropriate MTB PSD that minimizes inadvertent MOs. This would require OSMB to set an acceptable level of inadvertent safety risk exposure.

In the 1992 field season Jackson County Marine Deputies were observed patrolling the Gold Hill Study Reach several times. Based on the limited number of field and sample days spent on this study reach, the number of times that enforcement officers were observed indicates that the general level of enforcement presence is relatively high. This level of enforcement presence appears to be well balanced with the present level of estimated safety risk and conflicts under present MTB and FC use levels.

If in the future more daily MTB trips are scheduled, or more MTB craft are on each trip, or the FC use levels should increase, etc. MRS MOs could increase. This could lead to greater incidents of actual or near accidents, safety risk-related conflict and resource conflicts. Should increased uses lead to increased BS/C issues, several of the recreation management recommendations for the Hellgate Study Reach could be used. These may include more frequent sheriff's enforcement patrols and the development of annual BS/C meetings between MTB operators, pvt-JB operators, FC users, commercial driftboat guides, etc. facilitated by the Sheriff's Office.

6) General On-River Safety Risk and Conflict Issues:

Various non-FC uses were observed on the Gold Hill Study Reach that could lead to safety risks when interacting with MTBs. These user activity types are bed and bank angling and wading/swimming. These are also the same potentially conflicting user activity types as were observed on the Hellgate Study Reach, however on the Gold Hill Study Reach the numbers of users and locations of activity are very much less.

a) Bed and Bank Angling; Because of steep confining banks through most of the Gold Hill Study Reach most channel areas have steep shorelines, water tends to be relatively deep adjacent to the bank, and few broad riffles with classic geomorphic shapes occur. In addition, scour flows appear to be relatively rare resulting in thick bank vegetation in many area. These features leads to very low levels of fly-angling activity. Fly-angling was only observed at the riffle portion of Silica Hole. Bank angling was observed at many of the areas with convenient road access. These locations included the vicinity of the Gold Hill beach/Highway 99 bridge crossing RM 0.8 RR and RL), Rock Point (RM 3.5 RR) the lower end of Silica Hole (RM 4.4 RR), the area of Valley of the Rogue State Park (RM 6.5 to 6.8 RR), and various location throughout the study reach associated with adjacent private homes.

Similar to the findings for the Hellgate Study Reach, it is unlikely that bed or bank anglers will be using those portions of SOCs that would put them at inadvertent safety risk due to MTB operations when the best MTB operator skill and judgement are applied. Therefore should any safety risk incidents occur it is likely that they would be Overt MO situations. See section B: 8) a) of this chapter for a general discussion on MTB bed and bank angling safety risk interaction.

b) Swimming and Wading; Swimming and wading were observed at a limited number of locations. The primary sites were the Gold Hill beach (RM 0.8 RR), rock jumping and swimming at Rock Point (RM 3.5 RR), and limited wading at the Valley of the Rogue State Park (RM 6.7 RR). At all of these locations no MTB operational limitations were found that create potential for inadvertent safety risks. The levels of swimming/wading were so low during the 1992 field season that "No-Wake" buoys appeared to be uncalled for. Pvt-JBs were observed to occasionally pass very close to the Gold Hill beach which could endanger swimmers but the JBs have abundant space and visibility to avoid safety risks. Therefore these would be Overt MO situations. No recommendations are suggested for improving the safety risks associated with swimming/wading activities.

7) MTB Resource Conflict Issues:

During the BS/C Study field season a resource conflict issue was identified that could be expected to reduce FC user and landowner tolerance of MTB operations. For FC user there is some possibility that it could lead to induced BS/C issues at SOCs and in non-SOC portion of the study reach. While not directly inducing SR/C concerns, this issue could degrade resource values and lead to antagonism, and ultimately relate to poor on-river communication and possibly BS/C problems induced by FC behavior patterns. The source of this potential resource conflict is the configuration and use of on-board intercoms.

The placement and use pattern of the intercom system leads to the unnecessary projection of operator communications across large water surface areas. Intercoms mounted of windshields and pilot towers have been observed to project intelligible audio considerable distances over open water even while the MTB is operating on-plane. This increment of tour-related noise is unnecessary and can often add additional annoyance to other on-river and riparian users. This can, in part, lead to confrontational conflicts.

It is feasible to modify the configuration and use of passenger intercom systems such that the level of unnecessary noise is reduced and unnecessary resource conflict avoided. The intercom speakers could be moved to positions under the seats (or other suitable locations below the gunnels) and could be operated at low enough decibel levels to ensure that long distance projection does not occur. The intercom system could be operated at low power and used only when the MTB is off-plane to ensure that high decibel levels are not needed. Considering the small, intimate natural of the channel in the Gold Hill Study Reach and the small MTBs in use, it is even possible that the use of intercoms could be forgone entirely.

VII: BOATING SAFETY AND CONFLICT RECOMMENDATIONS

A: Introduction

The chapter presents recommendations for improving the BS/C conditions on both study reaches. The recommendations were developed through the SOC Assessment process, the SR/C Model results, on-river observations of the WRC study team, input from MTB operators and general river users contacted during the field season, and, for the Hellgate Study Reach, input and comments received from cosponsoring agencies and from members of the Focus Group (FG). Members of the FG also developed suggested recommendations for resolving safety problems on the Hellgate Study Reach.

B: Hellgate Study Reach

The development of safety risk and conflict resolution recommendations on the Hellgate Study Reach was a multi-stepped process and the Focus Group (FG) was intricately involved in the development of the assessment procedures, modeling approaches, and the development of BS/C recommendations.

Following the initial construction and configuration of the SOC Assessments and the SR/C Model by WRC-Environmental the members of the FG and WRC-Environmental staff developed lists of recommendations designed to reduce levels of BS/C concerns. These initial recommendations were based on field experience of the FG members and the WRC field staff, discussions held in the FG meetings, and results of initial SOC Assessment results.

The next step was an evaluation conducted by WRC-Environmental of the initial recommendations with respect to their implications to safety risk and conflict resolution. The evaluation used quantitative techniques using the initial SOC Assessments, initial SOC safety risk parameters, and initial SR/C Model, and also used qualitative techniques when initial recommendations could not be addressed by the assessment and modeling procedures. The evaluations of the initial recommendations were presented to the FG in the document "Draft Safety Recommendation Element, Safety Risk and Conflict Implications, Hellgate Study Reach", Appendix L. After a review of the initial recommendations and the evaluations of their potential implications, the FG members developed a list of final recommendations. The final recommendations from the FG, and additional recommendations developed by WRC-Environmental are listed in this section.

The FG input including specific comments on safety concerns, thresholds of acceptability, safety conflicts, resource conflicts, initial recommendation, and final recommendations is contained in the FG meeting notes, Appendix K.

Following the evaluation of the initial recommendations and the development of final recommendations, WRC-Environmental undertook a complete reevaluation of the SOC Assessments and the SR/C Model. This was undertaken to assure that all SOC Assessment procedures, mathematical computations, and modeling manipulations were as appropriate as possible. As a result of this process some of the final SOC Assessment safety risk parameters are different than the initial parameters used in the initial evaluation. The initial and final SOC safety risk parameters are presented in Table 6 so that the relative differences can be seen.

Changes in the SOC safety risk parameters were due to mainly four categories of modifications:

a) More precise PNS assessments incorporating a weighting process to accommodate oblique LOS across multiple FC routes resulting varying FC route lengths in the unseen portion of the SOC. On average these assessment changes tended to reduce the calculated PNSs.

Table 6

SOC SAFETY RISK PARAMETERS; INITIAL v. FINAL SOC ASSESSMENTS
Hellgate Study Reach

A; High Flow Conditions

SOCs	Initial Safety Risk Parameters PNS	PSR	PMO	Final Safety Risk Parameters PNS	PSR	PMO	Change PNS	PSR	PMO
Downstream Operations									
Middleton's Riffle	.407	.094	.038	.388	.064	.025	-.019	-.030	-.013
Applegate	.000	.000	.000	.000	.000	.000	.000	.000	.000
Whitehorse Riffle	.294	.600	.176	.297	.115	.034	+.003	-.485	-.142
Brushy Chutes	.148	.022	.003	.491	.038	.019	+.343	+.016	+.015
Two Bit Riffle	.008	.000	.000	.000	.000	.000	-.008	.000	.000
Hog Creek Island	.445	.471	.210	.328	.392	.129	-.117	-.079	-.081
Hellgate Riffle	.370	.165	.061	.374	.207	.077	+.004	+.042	+.016
Dunn Riffle	.435	.000	.000	.369	.073	.027	-.066	+.073	+.027
Ennis Riffle	.000	.000	.000	.000	.000	.000	.000	.000	.000
Upper Galice Chute	.622	.077	.048	.313	.053	.017	-.309	-.024	-.031
Lower Galice Chute	.346	.055	.019	.346	.004	.001	.000	-.051	-.018
Rocky Riffle	.377	.105	.040	.377	.091	.034	.000	-.014	-.005
Mark's Island	.331	.036	.012	.268	.016	.004	-.063	-.020	-.008
Bailey Riffle	.329	.594	.195	.270	.492	.133	-.059	-.102	-.063
Argo Riffle	.252	.329	.083	.117	.198	.023	-.135	-.131	-.060
Wooldridge Riffle	.070	.059	.004	.136	.002	.000	+.066	-.057	-.004
Upstream Operations									
Wooldridge Riffle	.125	1.00	.125	.249	.470	.117	+.124	-.530	-.008
Argo Riffle	.586	.914	.536	.362	.889	.322	-.224	-.025	-.214
Bailey Riffle	.261	.790	.206	.261	.766	.200	.000	-.024	-.006
Mark's Island	.470	.578	.272	.417	.784	.327	-.053	+.206	+.055
Rocky Riffle	.679	.415	.282	.415	.584	.242	-.264	+.169	-.039
Lower Galice Chute	.530	.942	.503	.498	.879	.438	-.036	-.063	-.065
Upper Galice Chute	.781	.209	.163	.776	.198	.154	-.005	-.011	-.010
Ennis Riffle	.000	.000	.000	.100	.018	.002	+.100	+.018	+.002
Dunn Riffle	.133	.638	.085	.101	.513	.052	-.032	-.125	-.033
Hellgate Riffle	.379	.774	.293	.210	.525	.110	-.169	-.249	-.183
Hog Creek Island	.610	.777	.474	.589	.850	.501	-.021	+.073	+.027
Two Bit Riffle	.000	.000	.000	.000	.000	.000	.000	.000	.000
Brushy Chutes	.555	.521	.289	.315	.530	.167	-.240	+.009	-.122
Whitehorse Riffle	.458	.721	.330	.316	.796	.252	-.142	+.075	-.079
Applegate	.000	.000	.000	.000	.000	.000	.000	.000	.000
Middleton's Riffle	.377	.739	.279	.394	.890	.351	+.017	+.151	+.072

B; Low Flow Conditions

SOCs	Initial Safety Risk Parameters PNS	PSR	PMO	Final Safety Risk Parameters PNS	PSR	PMO	Change PNS	PSR	PMO
Downstream Operations									
Middleton's Riffle	.429	.515	.221	.429	.507	.218	.000	-.008	-.003
Applegate	.000	.000	.000	.000	.000	.000	.000	.000	.000
Whitehorse Riffle	.294	.600	.176	.297	.843	.250	+.003	+.243	+.074
Brushy Chutes	.441	.312	.138	.586	.456	.267	+.145	+.144	+.130
Two Bit Riffle	.008	.000	.000	.000	.000	.000	-.008	.000	.000
Hog Creek Island	.445	.512	.228	.345	.418	.144	-.100	-.094	-.084
Hellgate Riffle	.370	.175	.065	.370	.373	.138	.000	+.198	+.073
Dunn Riffle	.435	.000	.000	.369	.073	.027	-.066	+.073	+.027
Ennis Riffle	.000	.000	.000	.000	.000	.000	.000	.000	.000
Upper Galice Chute	.662	.077	.051	.313	.053	.017	-.349	-.024	-.034
Lower Galice Chute	.346	.569	.197	.346	.468	.162	.000	-.101	-.035
Rocky Riffle	.377	.341	.129	.377	.327	.123	.000	-.014	-.005
Mark's Island	.331	.598	.198	.268	.016	.004	-.063	-.582	-.194
Bailey Riffle	.329	.633	.208	.270	.562	.152	-.059	-.071	-.057
Argo Riffle	.252	.329	.083	.117	.198	.023	-.135	-.131	-.060
Wooldridge Riffle	.046	.110	.005	.038	.043	.002	-.008	-.067	-.003
Upstream Operations									
Wooldridge Riffle	.125	1.00	.125	.249	.470	.117	+.124	-.530	-.008
Argo Riffle	.586	.914	.536	.362	.889	.322	-.224	-.025	-.214
Bailey Riffle	.261	.790	.206	.261	.766	.200	.000	-.024	-.006
Mark's Island	.470	.578	.272	.417	.784	.327	-.053	+.206	+.055
Rocky Riffle	.679	.415	.282	.415	.584	.242	-.264	+.169	-.039
Lower Galice Chute	.534	.942	.503	.498	.879	.438	-.036	-.063	-.065
Upper Galice Chute	.781	.209	.163	.776	.198	.154	-.005	-.011	-.010
Ennis Riffle	.000	.000	.000	.100	.018	.002	+.100	+.018	+.002
Dunn Riffle	.133	.638	.085	.101	.513	.052	-.032	-.125	-.033
Hellgate Riffle	.379	.782	.296	.342	.773	.264	-.037	-.009	-.032
Hog Creek Island	.610	.928	.566	.589	.916	.540	-.021	-.012	-.027
Two Bit Riffle	.000	.000	.000	.000	.000	.000	.000	.000	.000
Brushy Chutes	.652	.606	.395	.409	.755	.309	-.243	+.149	-.086
Whitehorse Riffle	.458	.721	.330	.316	.796	.252	-.142	+.075	-.078
Applegate	.000	.000	.000	.000	.000	.000	.000	.000	.000
Middleton's Riffle	.462	.353	.163	.437	.832	.364	-.025	+.479	+.201

Note: Based on 1992 channel conditions, craft use patterns, and assumed MTB PSDs.

b) Partially revised SOC Assessments utilizing additional information regarding MTB operational capabilities. Although these changes resulted in changed safety risk parameters, there is no consistent general trend of increasing or decreasing safety risk parameters. In the case of changes associated with MTB capabilities to set-down to drift, downstream PSRs at some SOCs were reduced.

c) Totally revised SOC Assessment procedures utilizing a new assessment framework. This type of assessment change was used at Hellgate Riffle for the low flow/downstream/pop-out SOC/scenario and at Wooldridge Riffle for high flow and low flow/upstream SOC/scenarios. These changes resulted in both small increases and decreases in PSRs and PMOs.

d) Math errors made during the initial SOC Assessments.

During the reevaluation of the SR/C Model it was discovered that the initial model construct did not route upstream MTBs runs through SOCs after they stopped to accommodate observed FC. This resulted in serious underestimations of PMOs on the SOC SR/C Curves for upstream operational scenarios. As a result, MRS MO estimate developed by the SR/C Model were also underestimated. However, because of the relatively low FC use level under present conditions the MOs were not as seriously underestimated as were the PMOs.

The relative magnitude of difference in MO estimates between the initial and final SOC/Assessment and SR/C Models for the Hellgate Study Reach are exemplified in Table 7 by the change in the baseline MRS MOs estimates by flow conditions.

Table 7

CHANGE IN BASELINE MRS MOs
Initial v. Final SOC Assessment and SR/C Model

Hellgate Study Reach

Flow Condition	Initial MRS MOs	Final MRS MOs
Low Flow	264	316
High Flow	226	244

Where reasonable, BS/C issues were evaluated and the implications of recommendations were addressed based on the final SOC Assessment safety risk parameters and the final SR/C Model. Because of time and funding limitations some BS/C issues and recommendations were only treated using the initial safety risk parameters and SR/C Model. When the initial safety risk parameters and the SR/C Model were used or if an issue was treated more thoroughly in the Draft Safety Recommendation Elements, Safety Risk and Conflict implications; Appendix L, an * is used. In those cases the quantitative MOs referenced are approximations and the appendix material should be reviewed.

The Hellgate Study Reach recommendations are addressed in two sections: Recommendation Elements, and Management Recommendation Scenarios. The recreation elements are the individual stand-alone recommendations developed to reduce safety risks and conflicts. They are referred to as "recommendation elements" because they were developed as suggestions separate from other suggestions and were not necessarily designed to work together to achieve a specific safety risk objective within specified management objectives or limitations. Various recommendation elements could be partially duplicative or counter productive. The "management recommendation scenarios" are sets of the recommendation elements combined to represent specific management approaches bounded by specific objectives such as target levels of safety risk exposure, levels of management involvement, and levels of impact to and/or dislocation of recreational users, etc. Table 8 is a summary listing of the various recreation management scenarios and the recommendation elements used.

1) Recommendation Elements:

Following is the list of final recommendation elements from both the FG and WRC-Environmental. At the fifth FG meeting the FG members provided a list of 26 initial BS/C recommendation elements. Following that FG meeting WRC-Environmental developed a list of an additional 19 initial BS/C recommendation elements. After a review of the potential implication of the initial recommendation elements, the FG members modified the initial recommendations into a final set of recommendation elements. Background discussions on the final recommendation elements can be found in the Boating Safety and Conflict Problems chapter in the report (Chapter VI), in the discussion of draft BS/C recommendations (Appendix L), and in Focus Group meeting notes (Appendix K). Those that were also initial recommendation elements are noted with a (*) and additional background discussion concerning them can be found in the two referenced appendices.

The A, B, and C denotations on the recommendation elements refer to recommendations that can reduce the levels of model estimated MRS MOs and reduced safety risk exposure (A), can result in conditions that reenforce circumstances that assure that SR/C Model assumptions are in use in the field and assure that MOs and Overt MOs are maintained at minimum levels (B), and can reduce the general level of conflict in the study reach such that resource conflicts are reduced and the ambiance that leads to BS/C concerns is mollified (C).

Focus Group Member Recommendation Elements;

A 1) Vegetation management (vegetation trimming) should be undertaken where appropriate on some of the islands or bank areas to improve visibility and safety.*

A 2) Develop alternative launch sites for the Hog Creek Ramp to help with congestion, traffic and overflow at Hog Creek Ramp and with on-river traffic in Hellgate Riffle.*
- Recommended access locations include;
  a) Jumpoff Joe Creek,*
  b) Hellgate/Galice Bridge.

A 3) Ramp patrol at the Hog Creek ramp to manage floatcraft launch traffic to accommodate passing JB/MTBs.*

A 4) MTB closure beyond Hellgate (Zigzag Creek) at "low water" levels.*
- Alternative recommended "low flow" thresholds include:
  a) Same as now used by the MTBs - close at top of Carpenter's Island @ <1400 cfs, close at Ennis Ramp @ <1300 cfs (as estimated at Zigzag Creek),*
  b) Close at Zigzag Cr. @ <1450 cfs (as estimated at Zigzag Creek),*
  c) Close at Zigzag Cr. @ <1600 cfs (as estimated at Zigzag Creek),
  d) Close at Zigzag Cr. @ <1800 cfs (as estimated at Zigzag Creek).*

A 5) MTB closure beyond Hellgate Canyon (Zigzag Creek) on holidays and weekends when also heavy use by rafts and other FC is experienced.*

A 6) Regular daily JB closures on a weekly basis.*
- Recommended closure schedules included;
  a) MTB closure on any 2 weekdays each week,*
  b) MTB closure on any 2 weekdays each week with compensation MTB trips allowed on other weekdays,*
  c) closures on any 3 days of each week to all motorized craft.

A 7) Use traffic spotters at certain SOCs at certain water levels to provide FC use information to MTB/JBs,*
- Traffic spotters to be used at;
  - Sentinel Rock @ <1250 cfs (as estimated at Zigzag Creek),*
  - Upper Galice Chute @ <1800 cfs (as estimated at Zigzag Creek),*
  - Lower Galice Chute @ <1800 cfs (as estimated at Zigzag Creek).*

A 8) In the future, BLM should eventually consider using limitations on FC use levels to reduce safety risk.*

B 9-13) Improve pvt-JB operator knowledge and skill:

B 9) Have more education of pvt-JB operators and review of on-river safety issues.*

B 10) Create a pvt-JB operators organization to increase level of training, the distribution of information, and to encourage new and out-of-area boaters to become knowledgeable.*

B 11) Develop a permit system to administer pvt-JB operators.*

B 12) Develop a license or certification for pvt-JB operators on technical rivers.*

B 13) Put together a search and rescue group using pvt-JB operators.*

B 14) MTBs should continue to travel in convoys.*

B 15) BLM should have a follow-up reporting procedure for JB incidents and MTBs should be more accountable.*

C 16-18) Improve on-river enforcement:

C 16) Increase the frequency of on-river enforcement personnel presence.*

C 17) On-river enforcement personnel should show discretion with enforcement; emphasize information, cooperation, and education not necessarily citations.*

C 18) Increase the level of compliance with safe floatcraft boating practices; enforce existing alcohol rules, enforce existing personal floatation device (PFD) rules.*

C 19-20) Improve FC user education:

C 19) Have handouts printed up which would be similar to the posted signage at the Galice Resort boat ramp. These handouts should be distributed by commercial outfitters to all persons renting inflatables.*

C 20) Post signs at all put-in points like the sign at the Galice Resort ramp.*

C 21) All MTBs should have a sign system indicating the number of the craft and the number of the boats in the convoy.*

C 22) There should be an operational speed or no wake rule when MTBs pass moored or beached floatcraft.*

C 23-24) Improve on-river communication between user activity types:

C 23) There be a coordinated effort to develop a system for on-river communications between JB operators and floatcraft users.*

C 24) The MTB operators should meet with driftboaters to explain on-river MTB operational needs and limitations, and develop "commonly understood" hand signals.*

WRC-Environmental Recommendation Elements:

A 25) Eliminate MTB uses in the study reach.

A 26) Modify Whitewater trip itineraries and schedules to reduce MTB/FC encounters and to reduce trip and seasonal safety risk exposure.*
- Modifications options include;
  a) 2 trips/day w/turn around at top of Mark's Island,*
  b) 2 trips/day w/turn around at Galice Ramp,*
  c) 2 trips/day w/turn around at top of Carpenter's Island,*
  d) 1 extended trip/day w/turn around at Galice Ramp,*
  e) Convert Whitewater trips to Scenic trips w/turn around at Zigzag Cr.,*

f) Eliminate entirely,*
g) 2 trips/day with flexible schedule and variable turn around point.*

A 27) Institute daily MTB closures on all Sundays and Mondays of the main recreation season.*

A 28) Institute the use of downstream operating JB speed restrictions in SOCs to reduce the PMOs.*

A 29) Institute the use of downstream operating minimum JB wait times at SOCs to reduce the PMOs.*

A 30) Traffic spotters use should be considered at all SOCs with visibility problems to reduce PMOs.*
- Parameters to consider should include;
  - Predicted PMOs at each SOC,
  - Level of potential hazard of MO situations at each SOC,
  - Schedule of traffic spotters and reduced PMOs relative to potential hazards.

A 31) Run pilot boats ahead of MTB trips to reduce safety risks.*

A 32) Use "Small" sized MTBs as lead boat on all MTB trips to reduce safety risks.*

B 33) Use "Medium" sized MTBs as lead boat on all trips.*

B 34) Conduct stop tests on all MTBs in use in the Study Reach, use physical stopping distances to calculate safe stopping distances, use safe stopping distances to recalculate the SOC Assessments, and re-run the SR/C Model to estimate present safety risk exposure and conflicts.*

B 35) Determine an acceptable MTB PSD based on a review of length, width and effectiveness of the set-down areas in both sections, a definition of acceptable MOs, and acceptable SSDs and use the acceptable PSD as a basis for prescribing acceptable MTBs (can vary with section).

B 36) BLM should conduct annual on-river review of SOC LOS thresholds with MTB operators, including ground truthing to confirm unseen portions, to establish LOS limitations and potential MO situations.

B 37) New SOC Assessment and SR/C modeling should be undertaken to estimate MO conditions when new conditions develop. Changes that could affect a new evaluation could include channel bottom topography, channel widths and curvature, vegetation patterns, MTB operational characteristics, FC SOC use characteristics, and FC user pattern, etc.*

B 38) MTB trips should be limited to 4 craft on Scenic Section itineraries and to 3 craft on Whitewater Section itineraries.*

B 39) Scenic Section MTB Trips with more than 5 MTBs should be broken into two distinct operational convoys not to exceed 4 craft each; gaps between craft should not exceed 1-3 mins, preferably operating within sight and total MTB convoy passage should not exceed 10 minutes. Each convoy should have a lead craft w/a craft number "flag" and operate no less than 30 minutes apart.*

B 40) Improve MTB passenger comfort on Whitewater MTB trips*.

B 41) Employ a second operator on all MTBs operating below Zigzag Creek.*

B 42) September MTB closure: Following the Labor Day weekend MTB trips should not pass the Applegate River confluence prior to 1200 hrs.*

B 43) Use 2 "No-Wake" buoys to delineate required off-plane JB operations through noted swimming areas.*

C 44) BLM and the Josephine Co. should institute daily on-river Marine Deputy patrols to improve visitor contact based recreation management and enforcement.*

C 45) BLM should sponsor and manage annual safety/conflict workshops between JB and non-JB users.*

C 46) All MTB convoys and trips should operate as distinct entities without intermingling and should maintain operating gaps of 30 minutes or more between convoys.*

C 47) MTB on-board intercoms should be modified to reduce the projection of interpretive discussions across the water surface.*

C 48) MTB hull paint schemes should de-emphasis company and boat names and emphasize boat identification numbers.*

C 49) BLM should stipulate MTB operator/owner BS/C issue cooperation though the commercial permittee process and conduct regular review of MTB operations.

2) Management Recommendation Scenarios:

The following are sets of BS/C management recommendation scenarios. Each scenario has the objective of achieving the maximum possible reduction in BS/C issues within the confines of different management objective and different levels of impact to recreational users. Each management scenario is defined, the appropriate recommendation elements are listed and a brief review of the implications of the scenario is provided. Table 8 summarizes the recreation management scenarios and lists the recommendation elements. The recommendation elements used in these management scenarios were selected by WRC-Environmental from the final list of recommendations provided by the FG members and the recommendation developed by WRC, and are given a Recommendation Element (RE) number that references the specific recommendation element as presented in the preceding section.

It should be noted that for nearly all SOC/scenarios in the Hellgate Study Reach there are possibilities for MOs. As defined in the BS/C Study a MO is an incident of unavoidable potential safety risk exposure under the best of circumstances. MOs are considered potential accident situations. To eliminate these types of safety risks, PMOs for all SOC/scenarios would have to be reduced to zero. PMOs could be reduced to zero by either; 1) eliminating JBs/MTBs from the study reach; 2) eliminating all other non-motorized recreational users from the study reach; or, 3) using a considerable manpower force at all the SOCs during MTB trip passes to effectively reduce the PNSs to zero. Therefore, short of eliminating BS/C concerns by removing either the motorized or the non-motorized activity types, or by investing in high levels of managing manpower to eliminate visibility problems, any BS/C management changes will reduce, but not eliminate, predicted MOs and the degree of safety risk exposure.

With this in mind one obvious way to eliminate BS/C concerns in the study reach is to prohibit pvt-JB and MTB operations. By definition all safety risks and conflicts associated with motorized/non-motorized encounters would be reduced to zero with the elimination of motorized boating. This would be the simplest strategy for management and enforcement and it would provide for the highest degree of safety risk and conflict reduction. It would also result in the highest degree of impact to the present activity type mix in the study reach. This is a potential management recommendation scenario and one that we recommend if managing agency objectives include both a zero tolerance for inadvertent safety risks and conflicts, as defined in this BS/C Study, and low management costs.

All but one of the management recommendation scenarios assume that MTB operations will be maintained as a viable business enterprise. In these management recommendation scenarios various management objectives can achieve varying levels of BS/C concern resolution using approaches that include varying MTB use levels, MTB craft and convoy management, and the involvement of management agencies. Therefore most of the management recommendation scenarios are aimed at reducing the degree of safety risk exposure while one scenario eliminates the safety risks by eliminating MTB activities.

For the purposes of discussion, "viable MTB business operations" is functionally defined as MTB access to the study reach that allows: 1) a consistent enough MTB trip itinerary schedule such that individual trips can be reliably marketed and run; and, 2) the level of MTB activity is great enough that the operation can be profitable. There is no predisposition in this functional definition toward a specific level of MTB activity nor level of profit so long as it is high enough to induce an owner/operator to maintain a MTB business.

a) *Management Scenario #1: Maximize safety risk and conflict reduction using active agency management while maintaining the basic status quo on MTB operations and FC activity*:

The object of this management scenario is the reduction BS/C concerns as much as possible through a combination of fully pro-active managing agency involvement in recreation BS/C management and modifications to the MTB operations that include only minor MTB trip management changes, and no capacity changes. Basic MTB operations are not effected.

Recommendations;

i) Develop a daily patrol schedule such that on every day of the MRS either a Sheriff's enforcement patrol or a BLM management patrol is on the study reach (RE: C 16 and C 44). These patrols should emphasize: 1) user contacts; 2) explanation of appropriate river etiquette and behavior; 3) encouraging the use of PFD's and other safety equipment, etc.; 4) developing communications between user types; and, 5) engaging users on the river that have been involved in BS/C incidents and to resolve the issues without acrimony (RE: C 17-18).

ii) BLM should conduct and manage BS/C issue meetings between all effected user activity types and users to: 1) identify BS/C issues; 2) develop potential resolutions to identified BS/C issues; 3) develop identity of individuals in various activity types to encourage constructive interaction on the river outside the meeting structure; and, 5) encourage constructive interaction between activity types at club meetings, etc. (RE: C 45).

iii) BLM should develop and maintain an active BS/C education program that emphasizes the dissemination of useful safety and on-river behavior information; 1) from commercial raft rental concerns to users; 2) to user group clubs; and, 3) from visitor centers to potential users, etc. (RE: B 9-10, C 19).

iv) Add clauses to MTB commercial operating permits to ensure greater management agency access to on-river operations with respect to BS/C issues (RE: C 49).

v) BLM should conduct annual on-river review of SOC LOS thresholds with MTB operators (RE; B 36).

vi) BLM should institute a MTB incident reporting procedure to: 1) form a repository for all incident reports prepared by any agency; and 2) to require incident reports from MTB incidents involving any on-plane contact with the channel bed or bank and any contact with the channel bed or bank or with any user or FC during evasive maneuvering regardless of consequences (RE: B 15).

vii) Conduct physical stopping tests (using variable loads and approach speeds) on all MTBs in use and reassess the Study Reach for BS/C issues (RE: B 34).

viii) The SOC Assessments and SR/C Modeling should be repeated, as needed, to assess for BS/C issues and concerns to account for changes in channel condition, changes in FC user pattern, and changes in MTB operational requirements (RE: B 37).

ix) Multi-craft MTB trips management should be improved to reduce safety risks, conflicts, and uncertainty:
- Multi-craft MTB trips should use a convoy approach (RE: B 14).
- MTB trip convoys should not exceed 5 craft in the Scenic Section, when trips exceed 5 MTBs two convoys of no more than 4 MTBs each should be formed (RE: B 39).
- MTB trip convoys should not exceed 3 craft in the Whitewater Section (RE: B 38).
- When multiple MTB craft are operating in a convoy, craft within the convoy should operate within sight, or at most within 1-3 minutes of other craft; total MTB convoy passage should not exceed 10 min. (RE: B 39).
- All lead MTB craft should display a "craft number flag" for the convoy and the craft with the "flag" should always be on the lead craft; or the "flag" should be transferred to passing craft as needed (RE: C 21).
- When a MTB trip has two convoys or when separate MTB trips are in the same vicinity, traveling in the same direction, at least a 30 min. operational gap between groups should be established and maintained

and each should have a lead craft with a craft number "flag". (RE: C 46).

x) Use 2 No-Wake buoys to delineate required off-plane JB operations through noted swimming areas (RE: B 43).

xi) Improve MTB passenger comfort on Whitewater MTB trips (RE: B 40).

xii) Other on-river conflict and resource value conflicts can be ameliorated by;
- Using more neutral MTB hull colors and reduced advertizing signage on the hulls so that craft number "flags" and MTB craft numbers/letters are more noticeable (RE: C 48).
- Modifying the on-board intercom systems to reduce noise projection (RE: C 47).

Potential Implications;

Increased recreation management agency involvement should improve BS/C conditions and reduce user activity group antagonism. Greater recreation management agency involvement in MTB safety should improve knowledge of on-river safety risk circumstances and situations for both management agency staff and MTB operators. Improved MTB convey management should reduce conflicts with FC and other users. The MTB convoy management practices would not reduce the MRS MO results of the SR/C Model but would reduce FC user uncertainty, safety risk related conflicts and resource conflict (in SOCs and non-SOC areas) and would improve the present BS/C situation. The continued use of "Large" sized MTBs as lead craft on many trips, instead of the modeled "medium" sized MTB, would increase the MRS MOs over those estimated in the SR/C Model.

b) *Management Scenario #2: Maximize safety risk and conflict reduction while minimizing impacts to MTB operations without regard to recreation management costs*:

The object of this management scenario is the reduction BS/C concerns as much as possible through a combination of fully pro-active managing agency involvement in recreation management and modifications to the MTB operations that include some cost elements, minor scheduling changes, and minor MTB trip management changes, but no capacity changes. The objective is to minimize levels of BS/C primarily through increased recreation management responsibilities and some modifications to MTB operations. Except for some cost issues, basic MTB business operations are not effected.

Recommendations;

i) Develop a daily patrol schedule such that on every day of the MRS either a Sheriff's enforcement patrol or a BLM management patrol is on the study reach (RE: C 16 and C 44). These patrols should emphasize: 1) user contacts; 2) explanation of appropriate river etiquette and behavior; 3) encouraging the use of PFD's and other safety equipment, etc.; 4) developing communications between user types; and, 5) engaging users on the river that have been involved in BS/C incidents and to resolve the issues without acrimony (RE: C 17-18).

ii) BLM should conduct and manage BS/C issue meetings between all effected user activity types and users to: 1) identify BS/C issues; 2) develop potential resolutions to identified BS/C issues; 3) develop identity of individuals in various activity types to encourage constructive interaction on the river outside the meeting structure; and, 5) encourage constructive interaction between activity types at club meetings, etc. (RE: C 45).

iii) BLM should develop and maintain an active BS/C education program that emphasizes the dissemination of useful safety and on-river behavior information; 1) from commercial raft rental concerns to users; 2) to user group clubs; and, 3) from visitor centers to potential users, etc. (RE: B 9-10, C 19).

iv) Add clauses to MTB commercial operating permits to ensure greater management agency access to on-river operations with respect to BS/C issues (RE: C 49).

Table 8

HELLGATE STUDY REACH
MATRIX OF MANAGEMENT SCENARIO RECOMMENDATION ELEMENTS

Recommendation Elements	Management Scenario #1	Management Scenario #2	Management Scenario #3	Management Scenario #4	Management Scenario #5	Management Scenario #6
Recreation Management						
C 44; Daily enforcement/management patrols:	X	X			X	
C 17; Patrols should emphasize info/cooperation, etc.:	X	X			X	
C 18; Increase enforcement/compliance of FC safety rules:	X	X			X	
B 49; BLM modify MTB commercial permit to require BS/C cooperation:	X	X	X	X	X	
B 15; Improve BLM incident reporting procedures:	X	X	X	X	X	
User Education						
B 45; BLM conduct annual BS/C meetings:	X	X	X	X	X	
B 9; Review on-river conditions w/pvt-JB operators:	X	X				
B 10; Develop pvt-JB operators organization:	X	X				
C 19; Develop handouts on safety/river etiquette for FC users:	X	X				
BS/C Management						
B 34; Run PSD tests on MTBs in use; develop new SOC and SR/C MO est.:	X	X	X	X	X	
B 36; Annual on-river review of SOC LOS limitations w/MTB operators:	X	X	X	X	X	
B 37; Repeat SOC Assessment and SR/C Modeling for new conditions:	X	X	X	X	X	
A 7; Use traffic spotters at some SOCs on heavy weekend days:			X			
A 7; Use traffic spotters at all SOCs, every day, all day:					X	
MTB Craft Management						
A 28; Require minimum SOC MTB speeds:		X		X		
A 29; Require minimum MTB wait times:		X		X		
B 41; Require 2 MTB operators in Whitewater Section:		X				
B 33; Require all lead craft to be "Medium" sized MTBs:		X				
B 32; Require all lead craft to be "Small" sized MTBs:				X		
B 35; Prescribe MTBs based on acceptable PSDs:				X		
B 40; Improve MTB passenger comfort:	X	X		X	X	
MTB Convoy Management						
B 14; Run in convoys:	X	X	X	X	X	
B 21; Improve lead craft "craft number flag" system:	X	X	X	X	X	
B 39; Convoys, 5 craft max. in Scenic Section:	X	X	X	X	X	
B 38; Convoys, 3 craft max. in Whitewater Section:	X	X	X	X	X	
B 39; Convoy craft operate within sight of each other:	X	X	X	X	X	
B 46; Convoys operate with >30 min. gap between convoys:	X	X	X	X	X	
Modifications to MTB Activities						
A 4d; MTB low flow closure in Whitewater Section:		X				
A 6a; MTB closures on 2 weekdays each week:			X			
A 25; Eliminate MTBs:						X
A 26f; Eliminate Whitewater MTB trip itinerary:			X			
A 27; MTB closures on Sun/Mon each week:			X			
B 42; After Labor Day eliminate AM MTB activity:			X			
Miscellaneous						
B 43; Use 2 No-Wake buoys at swimming sites:	X	X	X	X	X	X
C 47; Reconfigure MTB intercoms to reduce noise:	X	X	X	X	X	
C 48; Simplify MTB hull paint schemes:	X	X	X	X	X	

v) BLM should conduct annual on-river review of SOC LOS thresholds with MTB operators (RE; B 36).

vi) BLM should institute a MTB incident reporting procedure to: 1) form a repository for all incident reports prepared by any agency; and 2) to require incident reports from MTB incidents involving any on-plane contact with the channel bed or bank and any contact with the channel bed or bank or with any user or FC during evasive maneuvering regardless of consequences (RE: B 15).

vii) Conduct physical stopping tests (using variable loads and approach speeds) on all MTBs in use and reassess the Study Reach for BS/C issues (RE: B 34).

viii) The SOC Assessments and SR/C Modeling should be repeated, as needed, to assess for BS/C issues and concerns to account for changes in channel condition, changes in FC user pattern, and changes in MTB operational requirements (RE B 37).

ix) All MTB trips should have "Medium" sized MTBs as lead craft (RE: B 33).

x) Reduce the safety risk exposures (PMOs) at various SOCs by using MTB speed restrictions (RE: A 28) and by instituting minimum MTB wait times (RE: A 29).

xi) Two operators should be used on all MTBs running in the Whitewater Section (RE: B 41).

xii) At flows less than 1800 cfs the Whitewater trip itineraries should turn around at Zigzag Creek and return to Grants Pass (RE: A 4d)

xiii) Multi-craft MTB trips management should be improved to reduce safety risks, conflicts, and uncertainty:
- Multi-craft MTB trips should use a convoy approach (RE: B 14).
- MTB trip convoys should not exceed 5 craft in the Scenic Section, when trips exceed 5 MTBs two convoys of no more than 4 MTBs each should be formed (RE: B 39).
- MTB trip convoys should not exceed 3 craft in the Whitewater Section (RE: B 38).
- When multiple MTB craft are operating in a convoy, craft within the convoy should operate within sight, or at most within 1-3 minutes of other craft; total MTB convoy passage should not exceed 10 min. (RE: B 39).
- All lead MTB craft should display a "craft number flag" for the convoy and the craft with the "flag" should always be on the lead craft; or the "flag" should be transferred to passing craft as needed (RE: C 21).
- When a MTB trip has two convoys or when separate MTB trips are in the same vicinity, traveling in the same direction, at least a 30 min. operational gap between groups should be established and maintained and each should have a lead craft with a craft number "flag". (RE: C 46).

xiv) Use 2 No-Wake buoys to delineate required off-plane JB operations through noted swimming areas (RE: B 43).

xv) Improve MTB passenger comfort on Whitewater MTB trips (RE: B 40).

xvi) Other on-river conflict and resource value conflicts can be ameliorated by;
- Using more neutral MTB hull colors and reduced advertizing signage on the hulls so that craft number "flags" and MTB craft numbers/letters are more noticeable (RE: C 48),
- Modifying the on-board intercom systems to reduce noise projection (RE: C 47).

Potential Implications;

Increased involvement of recreation management agencies should improve BS/C conditions and reduce user activity group antagonism. Greater recreation management agency involvement in MTB safety should improve knowledge of on-river safety risk circumstances and situations for both management agency staff and MTB operators. Improved MTB convey management should reduce conflicts with FC and other users. The MTB convoy management practices would not reduce the MRS MO results of the SR/C Model but would reduce FC user uncertainty, safety risk related conflicts and resource conflict (in SOCs and non-SOC areas) and would improve the present BS/C

situation. The transition to "Medium" sized MTBs as lead craft on all trips would reduce actual on-river safety risks but no changes in the SR/C Model MRS MO output would result. The use of minimum MTB speeds and stopping times could reduce safety risks but only for downstream operations and enforcement would be difficult. Analysis using initial SOC safety risk parameters and the SR/C Model functions indicate that MRS MOs could be reduced by 5-20%. The elimination of MTB activity in the Whitewater Section at low flows would result in about a 54% reduction in safety risk exposure (See Table 5) and a significant reduction in safety risk-related conflicts on days when flows are <1800 cfs as computed at Zigzag Creek. The seasonal impact of this low flow closure would depend on the day-types and number of days with flows less than 1800 cfs. These trips are assumed to run to Zigzag Creek to turn around so there would be no reduction in MTB daily passenger capacity. Other threshold flows could be selected, ie. 1600 or 1450 cfs. which would result in slightly fewer closure days in any given MRS.

c) *Management Scenario #3: Maximize reductions in safety risks and conflicts by modifying MTB operational patterns as necessary while maintaining basically viable MTB business operations*:

This BS/C management scenario maximizes the reduction of BS/C issues by altering MTB craft, convoy, and trip itinerary schedules and adopting a minimal level of adequate management agency responsibilities. This includes reduced areas of MTB operation and days of operation resulting in reduced, but still economically viable, MTB use levels.

Recommendations;

i) BLM should conduct and manage BS/C issue meetings between all effected user activity types and users to: 1) identify BS/C issues; 2) develop potential resolutions to identified BS/C issues; 3) develop identity of individuals in various activity types to encourage constructive interaction on the river outside the meeting structure; and, 5) encourage constructive interaction between activity types at club meetings, etc. (RE: C 45)

ii) Add clauses to MTB commercial operating permits to ensure greater management agency access to on-river operations with respect to BS/C issues (RE: C 49)

iii) BLM should conduct annual on-river review of SOC LOS thresholds with MTB operators (RE; B 36).

iv) BLM should institute a MTB incident reporting procedure to: 1) form a repository for all incident reports prepared by any agency; and 2) to require incident reports from MTB incidents involving any on-plane contact with the channel bed or bank and any contact with the channel bed or bank or with any user or FC during evasive maneuvering regardless of consequences (RE: B 15).

v) Reduce the safety risk exposures (PMOs) at various SOCs by using MTB speed restrictions (RE: A 28) and by instituting minimum MTB wait times (RE: A 29).

vi) Conduct physical stopping tests (using variable loads and approach speeds) on all MTBs in use and reassess the Study Reach for BS/C issues (RE: B 34).

vii) The SOC Assessments and SR/C Modeling should be repeated, as needed, to assess for BS/C issues and concerns to account for changes in channel condition, changes in FC user pattern, and changes in MTB operational requirements (RE B 37).

viii) Eliminate the Whitewater MTB trips from the seasonal schedule (RE: A 26f).

ix) Reduce safety risks, conflicts, and resource conflicts in the Scenic Section by:
- Instituting regular weekly MTB closures to eliminate all safety risk, conflict, and resource conflict on a regular basis; alternatives include;
  - 2 weekdays a week (RE: A 6a),
  - Sun/Mon each week (RE: A 27)
- Change the morning MTB Applegate passage time limit to 1200 hrs after the Labor Day weekend to allow for reduced safety risks, conflict, and resource value conflicts with anglers (RE: B 42).

x) Multi-craft MTB trips management should be improved to reduce safety risks, conflicts, and uncertainty:
- Multi-craft MTB trips should use a convoy approach (RE: B 14).
- MTB trip convoys should not exceed 5 craft in the Scenic Section, when trips exceed 5 MTBs two convoys of no more than 4 MTBs each should be formed (RE: B 39).
- MTB trip convoys should not exceed 3 craft in the Whitewater Section (RE: B 38).
- When multiple MTB craft are operating in a convoy, craft within the convoy should operate within sight, or at most within 1-3 minutes of other craft; total MTB convoy passage should not exceed 10 min. (RE: B 39).
- All lead MTB craft should display a "craft number flag" for the convoy and the craft with the "flag" should always be on the lead craft; or the "flag" should be transferred to passing craft as needed (RE: C 21).
- When a MTB trip has two convoys or when separate MTB trips are in the same vicinity, traveling in the same direction, at least a 30 min. operational gap between groups should be established and maintained and each should have a lead craft with a craft number "flag". (RE: C 46).

xi) Add MTB company employee traffic spotters at several SOCs (Middleton's, Whitehorse, Brushy, Hog Creek Islands, and Sentinel Rock) all day, every day, for the purpose of informing MTB operators of the presence of unseen FC (RE: A 7).

xii) Use 2 No-Wake buoys to delineate required off-plane JB operations through noted swimming areas (RE: B 43).

xiii) Other on-river conflict and resource value conflicts can be ameliorated by;
- Using more neutral MTB hull colors and reduced advertizing signage on the hulls so that craft number "flags" and MTB craft numbers/letters are more noticeable (RE: C 48),
- Modifying the on-board intercom systems to reduce noise projection (RE: C 47).

Potential Implications;

Using this minimal level of increased recreation management agency involvement BS/C conditions should improve and user activity group antagonism should be reduced. Greater recreation management agency involvement in MTB safety should improve knowledge of on-river safety risk circumstances and situations for both management agency staff and MTB operators. Improved MTB convey management should reduce conflicts with FC and other users. The MTB convoy management practices would not reduce the MRS MO results of the SR/C Model but would reduce FC user uncertainty, safety risk related conflicts and resource conflict (in SOCs and non-SOC areas) and would improve the BS/C situation. The elimination of Whitewater MTB trip itineraries could decrease safety risk exposure for the MRS by about 70% (See Table 5) and would significantly reduce safety risk-related conflicts. The MTB passenger capacity probably would not be reduced because the Whitewater trip capacity can be accommodated by increasing craft numbers on MTB trips in the Scenic Section (so long as convoys are not increased to over 5 MTBs). In addition, the loss of the "Whitewater trip marketing draw" is probably more important to the MTB owner/operator and the MTB operators than to the potential passengers. It is unlikely that demand for MTB services will be diminished should the Whitewater trips no longer be offered. If the weekly Scenic Section MTB closures were added, additional safety risk exposure reductions would occur. Table 5 indicates that for high flow conditions, reducing the MRS Scenic Section MTB schedules from 68 days to 42 days would reduce the MRS weekday MOs from about 41 to about 26; a reduction of about 10% relative to the total MRS MOs (244). About 80% of the predicted MRS MOs would be eliminated by the two closures. The weekly closure would have significant resource conflict resolution potential but would reduce the MRS MTB passenger capacity and lead to reduced study reach visitation. Compensating MTB trips on "open days" would increase MRS MOs above baseline conditions. The use of MTB employee traffic spotters at several SOCs in the Scenic Section could eliminate most of the remaining MRS MOs. The elimination of AM MTB activity after the Labor Day weekend would reduce MOs, safety risk-related conflicts, and resource conflict issues with bed, bank, and driftboat anglers during that season. While the weekly MTB closures may result in some reduce MTB trip supply, the AM post-Labor Day closure should not due to lower MTB space demand in September.

d) *Management Scenario #4: Maximize reductions in safety risks and conflicts by modifying the MTB fleet configuration as necessary, while maintaining basically viable MTB business operations*:

This BS/C management scenario maximizes the reduction of BS/C issues by altering MTB craft characteristics to reduce safety risk exposure; while still economically viable, MTB use levels.

Recommendations;

i) BLM should conduct and manage BS/C issue meetings between all effected user activity types and users to: 1) identify BS/C issues; 2) develop potential resolutions to identified BS/C issues; 3) develop identity of individuals in various activity types to encourage constructive interaction on the river outside the meeting structure; and, 5) encourage constructive interaction between activity types at club meetings, etc. (RE: C 44)

ii) BLM Add clauses to MTB commercial operating permits to ensure greater management agency access to on-river operations with respect to BS/C issues (RE: C 49)

iii) BLM should conduct annual on-river review of SOC LOS thresholds with MTB operators (RE; B 36).

iv) BLM should institute a MTB incident reporting procedure to: 1) form a repository for all incident reports prepared by any agency; and 2) to require incident reports from MTB incidents involving any on-plane contact with the channel bed or bank and any contact with the channel bed or bank or with any user or FC during evasive maneuvering regardless of consequences (RE: B 15).

v) Reduce the safety risk exposures (PMOs) at various SOCs by using MTB speed restrictions (RE: A 28) and by instituting minimum MTB wait times (RE: A 29).

vi) Use "Small" sized MTBs as lead boat on all MTB trips to reduce safety risks (A 32).

OR

vii) Determine acceptable MTB operational characteristics based on set-down dimensions and acceptable MO tolerance (B 35).

viii) The SOC Assessments and SR/C Modeling should be repeated, as needed, to assess for BS/C issues and concerns to account for changes in channel condition, changes in FC user pattern, and changes in MTB operational requirements (RE B 37).

ix) Multi-craft MTB trips management should be improved to reduce safety risks, conflicts, and uncertainty:
- Multi-craft MTB trips should use a convoy approach (RE: B 14).
- MTB trip convoys should not exceed 5 craft in the Scenic Section, when trips exceed 5 MTBs two convoys of no more than 4 MTBs each should be formed (RE: B 39).
- MTB trip convoys should not exceed 3 craft in the Whitewater Section (RE: B 38).
- When multiple MTB craft are operating in a convoy, craft within the convoy should operate within sight, or at most within 1-3 minutes of other craft; total MTB convoy passage should not exceed 10 min. (RE: B 39).
- All lead MTB craft should display a "craft number flag" for the convoy and the craft with the "flag" should always be on the lead craft; or the "flag" should be transferred to passing craft as needed (RE: C 21).
- When a MTB trip has two convoys or when separate MTB trips are in the same vicinity, traveling in the same direction at least a 30 min. operational gap between groups should be established and maintained and each should have a lead craft with a craft number "flag". (RE: C 46).

x) Use 2 No-Wake buoys to delineate required off-plane JB operations through noted swimming areas (RE: B 43).

xi) Improve MTB passenger comfort on Whitewater MTB trips (RE: B 40).

xii) Other on-river conflict and resource value conflicts can be ameliorated by;
- Using more neutral MTB hull colors and reduced advertizing signage on the hulls so that craft number "flags" and MTB craft numbers/letters are more noticeable (RE: C 48),
- Modifying the on-board intercom systems to reduce noise projection (RE: C 47).

Potential Implications;

The use of smaller MTBs with shorter PSDs would result in shorter SSDs, shorter SOCs, fewer FC to interact with in SOCs, increased set-down area width MO thresholds, and increased number of useable set-down areas within SOCs. This would lead to reduced safety risk parameters and MOs for many downstream SOC/scenarios and for some upstream SOC/scenarios. The reductions in MOs through the use of "Small" sized MTBs would need to be assessed by conducting PSD tests and conducting a new round of SOC Assessments and SR/C modeling. If an acceptable MTB PSD was to be prescribed, acceptable MO thresholds and acceptable levels of MRS MOs would need to be established. The results of smaller MTBs with shorter PSD could include substantial decreases in downstream operating safety risk exposure. Since during upstream operations the LOS thresholds would remain a "barrier" to safe operations, safety risk exposure reductions would only result from better FC float-by circumstances and the percentage change could be slight. Safety risk exposure could be further reduced by adding other recommendation elements that are listed in other Management Scenarios such as, low flow Whitewater Section MTB closure, the elimination of Whitewater trip itineraries, regular weekday MTB closures, post-Labor day AM closure, MTB convoy management, and traffic spotters, etc. Unless the daily MTB craft number limitations are changed from 19/day, the use of smaller MTBs would lead to reduced daily MTB passenger capacity and increased demand pressure on the seating supply. If in compensation additional MTB craft trips are allowed, impacts on recreational values to other on-river users could be expected to increase. If in compensation additional MTB trip itinerary schedules are allowed, increases in the MRS MO estimates could be expected.

e) *Management Scenario #5: Maximize safety risk and conflict reduction using active agency management and active MTB owner/operator involvement in BS/C management while maintaining basic MTB operational status quo*:

This BS/C management scenario reduces BS/C concerns to the maximum possible extent through a combination of fully pro-active managing agency involvement in recreation BS/C management and maximum MTB owner/operator cooperation with, and contribution to, BS/C management, but avoiding reductions in MTB activity levels.

Recommendations;

i) Develop a daily patrol schedule such that on every day of the MRS either a Sheriff's enforcement patrol or a BLM management patrol is on the study reach (RE: C 16 and C 44). These patrols should emphasis: 1) user contacts; 2) explanation of appropriate river etiquette and behavior; 3) encouraging the use of PFD's and other safety equipment, etc.; 4) developing communications between user types; and, 5) engaging users on the river that have been involved in BS/C incidents and to resolve the issues without acrimony (RE: C 17-18).

ii) BLM should conduct and manage BS/C issue meetings between all effected user activity types and users to: 1) identify BS/C issues; 2) develop potential resolutions to identified BS/C issues; 3) develop identity of individuals in various activity types to encourage constructive interaction on the river outside the meeting structure; and, 5) encourage constructive interaction between activity types at club meetings, etc. (RE: C 45).

iii) Add clauses to MTB commercial operating permits to ensure greater management agency access to on-river operations with respect to BS/C issues (RE: C 49).

iv) BLM should conduct annual on-river review of SOC LOS thresholds with MTB operators (RE; B 36).

v) Conduct physical stopping tests (using variable loads and approach speeds) on all MTBs in use and reassess the Study Reach for BS/C issues (RE: B 34).

vi) The SOC Assessments and SR/C Modeling should be repeated, as needed, to assess for BS/C issues and concerns to account for changes in channel condition, changes in FC user pattern, and changes in MTB operational requirements (RE B 37).

vii) BLM should institute a MTB incident reporting procedure to: 1) form a repository for all incident reports prepared by any agency; and 2) to require incident reports from MTB incidents involving any on-plane contact with the channel bed or bank and any contact with the channel bed or bank or with any user or FC during evasive maneuvering regardless of consequences (RE: B 15).

viii) Multi-craft MTB trips management should be improved to reduce safety risks, conflicts, and uncertainty:
- Multi-craft MTB trips should use a convoy approach (RE: B 14).
- MTB trip convoys should not exceed 5 craft in the Scenic Section, when trips exceed 5 MTBs two convoys of no more than 4 MTBs each should be formed (RE: B 39).
- MTB trip convoys should not exceed 3 craft in the Whitewater Section (RE: B 38).
- When multiple MTB craft are operating in a convoy, craft within the convoy should operate within sight, or at most within 1-3 minutes of other craft; total MTB convoy passage should not exceed 10 min. (RE: B 39).
- All lead MTB craft should display a "craft number flag" for the convoy and the craft with the "flag" should always be on the lead craft; or the "flag" should be transferred to passing craft as needed (RE: C 21).
- When a MTB trip has two convoys or when separate MTB trips are in the same vicinity, traveling in the same direction, at least a 30 min. operational gap between groups should be established and maintained and each should have a lead craft with a craft number "flag" (RE: C 46).

ix) MTB company employee traffic spotters should be used at all SOCs with LOS issues all day, every day, for the purpose of informing MTB operators of the presence of unseen FC (RE: A 7).

x) Use 2 No-Wake buoys to delineate required off-plane JB operations through noted swimming areas (RE: B 43).

xi) Improve MTB passenger comfort on Whitewater MTB trips (RE: B 40).

xii) Other on-river conflict and resource value conflicts can be ameliorated by;
- Using more neutral MTB hull colors and reduced advertizing signage on the hulls so that craft number "flags" and MTB craft numbers/letters are more noticeable (RE: C 48),
- Modifying the on-board intercom systems to reduce noise projection (RE: C 47).

Potential Implications;

Increased recreation management agency involvement should improve BS/C conditions and reduce use activity group antagonism. Greater recreation management agency involvement in MTB safety should improve knowledge of on-river safety risk circumstances and situations for management agency staff and MTB operators. Improved MTB convey management should reduce conflicts with FC and other users. The MTB convoy management practices would not reduce the MRS MO results of the SR/C Model but would reduce FC user uncertainty, safety risk related conflicts and resource conflict (in SOCs and non-SOC areas) and improve the BS/C situation. The use of MTB employee traffic spotters at all the SOCs with LOS thresholds could eliminate all modeled MRS MOs. The elimination of AM MTB trips after Labor Day weekend would reduce MOs and conflict issues with bed, bank, and driftboat anglers. The elimination of the AM trips after Labor Day should not reduce the MTB space supply but would reduce the number of trip schedule options available to visitors.

f) *Management Scenario #6: Maximize safety risk and conflict reduction using relying solely on modifications to the MTB operations without regard to economic viability*:

This BS/C management scenario reduces BS/C concerns to the maximum possible extent using only modifications to MTB operations.

Recommendations;

i) Eliminate MTB uses in the study reach (A 25).

ii) Use 2 No-Wake buoys to delineate required off-plane JB operations through noted swimming areas (RE: B 43).

Potential Implications;

The elimination of the MTBs from the study reach would result the elimination of all safety risk exposure, safety risk-related conflict and resource conflict induced by the MTB/non-motorized recreational user encounters. The remaining motorized/non-motorized safety risk exposure and conflicts would be associated with pvt-JB uses. The removal of MTBs from the study reach would eliminate source of most of the JB operator knowledge of JB navigation in the study reach. This could lead to gradual diminution of pvt-JB operator knowledge and perhaps a gradual decline in the number of pvt-JBs in use. The elimination of MTB activities would be an easy management/enforcement situation for BLM. The loss of MTBs would lead to the elimination of one recreational activity type and the reduction in annual users of the study reach by about 70,000.

C: Gold Hill Study Reach

The development of safety risk and conflict resolution recommendations on the Gold Hill Study Reach was a result of on-river observations, the SOC Assessments undertaken, and conversations with users and the MTB owner/operator and the local marine officer. In addition carry-over in-put from the Hellgate Focus Group was used when appropriate.

Due to the fact that the BS/C issues on the Gold Hill Study Reach were comparatively minor, the following recommendation elements are presented as ways that present and/or future BS/C concerns could be reduced. No management scenarios were developed to group various recommendation elements into discrete sets because no agency has general recreation management authority and is in the position to trade improved BS/C concerns with recreation management and costs concerns. The recommendation elements are organized into three groups with the intention that, pending varying use levels and management interest, different actions would be appropriate. These conditions are: 1) present conditions; 2) present conditions with an active BS/C concerns by OSMB; and, 3) future conditions with greater uses and greater BS/C concerns.

As for the Hellgate Study Reach, the A, B, and C denotations on the following recommendation elements refer to recommendations that can reduce the levels of model estimated MRS MOs and reduced safety risk exposure (A), can result in conditions that reenforce circumstances that assure that SR/C Model assumptions are in use in the field and assure that MOs and Overt MOs are maintained at minimum levels (B), and can reduce the general level of conflict in the study reach such that resource conflicts are reduced and the ambiance that leads to BS/C concerns is mollified (C).

Present Condition Recommendation Elements;

A 1) MTB closure above Rock Point on holidays and weekends when also heavy use by rafts and other FC is experienced.

A 2) Institute the use of downstream operating minimum JB wait times at SOCs to reduce the PMOs.

B 3) Limit MTBs to "Small" sized craft

B 4) Conduct annual on-river review of SOC LOS thresholds with MTB operators, including ground truthing to confirm unseen portions, to establish LOS limitations and potential MO situations.

C 5) MTB on-board intercoms should be modified to reduce the projection of interpretive discussions across the water surface.

Present Condition/Active Management Recommendation Elements;

B 6) Conduct stop tests on all MTBs in use in the Study Reach, use physical stopping distances to calculate safe stopping distances, use safe stopping distances to recalculate the SOC Assessments, develop a FC Use Distribution Model and run an SR/C Model to estimate present level of safety risk exposure and conflicts.

B 7) Determine an acceptable MTB PSD based on a review of length, width and effectiveness of the set-down areas in both sections, a definition of acceptable MOs, and acceptable SSDs and use the acceptable PSD as a basis for prescribing acceptable MTBs.

B 8) New SOC Assessment and SR/C modeling should be undertaken to estimate MO conditions when new conditions develop. Changes that could affect a new evaluation could include channel bottom topography, channel widths and curvature, vegetation patterns, MTB operational characteristics, FC SOC use characteristics, and FC user pattern, etc.

Future Condition Recommendation Elements;

A 9) Traffic spotters use should be considered at all SOCs with visibility problems to reduce PMOs.
- Parameters to consider should include;
  - Predicted PMOs at each SOC,
  - Level of potential hazard of MO situations at each SOC,
  - Schedule of traffic spotters and reduced PMOs relative to potential hazards.

A 10) In the future, should FC traffic increase, regular daily JB closures on a weekly basis.
- Closure schedules could include;
  a) MTB closure on any 2 weekdays each week,
  b) MTB closure on any 2 weekdays each week with compensation MTB trips allowed on other weekdays,
  c) closures on any 3 days of each week to all motorized craft.
  d) closures on all Sundays and Mondays of the main recreation season.

B 11-14) Improve pvt-JB Operator Knowledge and Skill:

B 11) Have more education of pvt-JB operators and review of on-river safety issues.

B 12) Create a pvt-JB operators organization to increase level of training, the distribution of information, and to encourage new and out-of-area boaters to become knowledgeable.

B 13) Develop a permit system to administer pvt-JB operators.

B 14) Develop a license or certification for pvt-JB operators on technical rivers.

C 16-17) Improve On-River Communication Between User Types:

C 16) A management agency should coordinate the effort to develop a system for on-river communications between JB operators and floatcraft users.

C 17) The MTB operators should meet with driftboaters to explain on-river MTB operational needs and limitations, and develop "commonly understood" hand signals.

C 18) Jackson County Sheriff's Office should sponsor and manage annual safety/conflict workshops between JB and non-JB users.

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ACRONYMS and ABBREVIATIONS

BLM - Bureau of Land Management

BS/C - Boating Safety and Conflict

cfs - Cubic Feet per Second

FC - FloatCraft

FG - Focus Group

ft - Feet

ft/sec - Feet per Second

HSR - Hazard Severity Rating

ISR - Inherent Safety Risk

JB - JetBoats

JB/MTB - JetBoats/Motorized Tour Boats

LOS - Line Of Sight

min - Minutes

MO - Mutual Occupation occurrences

mph - Miles per Hour

MRS - Main Recreation Season

MTB - Motorized Tour Boats

OSMB - Oregon State Marine Board

PFD - Personal Floatation Device

PI - Probability of run Initiation

PMO - Probability of Mutual Occupation

PNS - Probability of Not being Seen

PSD - Physical Stopping Distance

PSR - Probability of Safety Risk

Pvt-JB - Private Jetboat

RAMP - Recreation Area Management Plan

RC - River Center

RIP - Run Initiation Point

RL - River Left

RM - River Mile

RR - River Right

sec - Seconds

SOC - Site Of Concern

SR/C - Safety Risk and Conflict

SSD - Safe Stopping Distance

ST - Safety Threshold

USDI - US Department of the Interior

USCG - US Coast Guard

USGS - US Geological Survey

UUC - Unit Use Curve

WRC - WRC-Environmental

DEFINITION OF TERMS

Accident; In this BS/C Study it is defined as an incident between motorized and non-motorized activities that could result in equipment damage, personal injury, of the loss of life.

Activity type (group); A unified cluster of similar recreationists or recreational activities when juxtaposed to other types or groups.

Bed and Bank (users, activity types); Recreationists that predominantly use the bed and bank of the channel. These users can be bank and wading anglers, recreational waders, or users of the shoreline.

Boating Safety/Conflict (BS/C); A general term referring to the safety and conflict issues as defined and addressed in this study. (See "Safety Risk" and "Safety Risk-Related Conflict".)

Conflict; In this BS/C Study, a general term referring to interactions between motorized and non-motorized recreational activities that result in activity adjustments to accommodate conflicting activities, or the degradation of recreational resource values. (See "Safety Risk-Related Conflict" and "Wait Related Conflict".)

Day-types; Categories of days of the week with similar FC use levels; weekdays, weekend-days, holidays.

Driftboat; A hard shell dory type craft, powered by oars and used primarily for drift angling in technical rivers. If these craft are used for river tour recreation instead of angling they are considered as FC in this BS/C Study.

Effective Channel Area; That portion of the channel (usually width) within which a craft can operate. Typically used in reference to MTBs when effective widths can be limited by shoals and/or the spatial distribution of navigational hazards.

Fault-Tree Risk Assessment; A risk assessment approach applied when there are multiple potential risk elements that are sequential and interdependent, and risk elements of an incident follow variable paths depending on the physical situation and operator decisions. The assessment operates as a cascading evaluation in which the probabilities of combined sets of risk elements can by estimated.

Floatcraft (FC); Any non-motorized craft used to float in the study reach including rafts, inner tubes, rubber duckies, kayaks, driftboats (when used for river tour recreation) etc.

Floatcraft Use Distribution Model; The model which predicts the time of day and spatial distribution of FC throughout a study reach.

Glide; The glide is the area at the top of riffles before the tongue where water depths are shallowing and water velocities are increasing slightly. The glide leads to the tongue where the diagonal bank hydraulics cause a narrowing of the main current area which increases water velocity in spite of often deeper water. In the study area the glide is often located between the MTB set-down threshold and the tongue.

Gold Hill Study Reach; The 9.6 mile portion of the study area in the Gold Hill area of Jackson County.

Hazard Severity Rating (HSR); A subjective evaluation of the relative consequence severity of specific MO elements within each SOC for each SOC/scenario. It is based on the expected MTB operational mode, channel conditions, and expected FC spatial distribution. Factors considered include the likelihood that the MO will occurs, the likelihood that the MO will result in an accident, and the possible severity of an accident.

Hellgate Study Reach; The 33.3 mile portion of the study area between Grants Pass and the Grave Creek access location.

Inadvertent Mutual Occupation (Inadvertent MO); See Mutual Occupation.

Inherent Safety Risk (ISR); This is a standard measure for comparing the safety risk characteristics of the SOC/scenarios as a function of only channel/hydraulic conditions, the craft use patterns, and MTB operational characteristics and not related to use levels and the temporal distribution of activities. The ISR is based on the likelihood that a MO situation will develop if one FC is in the SOC at the moment a MTB arrives at the RIP. It is mathematically equivalent to the PMO in the Single-FC SOC Assessment process.

Jetboat (JB); A watercraft powered by an inboard or outboard motor and an enclosed impeller-jet unit as opposed to an exposed propeller.

Knowledge Field; That portion of the SOC within which the MTB operator can infer FC use patterns as the duration of a MTB stop at a SOC RIP increases. For downstream MTB operations it includes the view field from the RIP as well as the extension of inferred FC activities below the LOS threshold as time passes. For upstream MTB operations it does not extend above the LOS threshold and is the same as the view field.

Line of Sight (LOS); The edge of a visual field from a specified location into the channel ahead. Typically used in reference to a MTB operator's field of view from a SOC RIP as limited by channel curvature and/or bank and vegetation conditions.

Line of Sight Threshold; The point in a SOC along the FC route(s) where FC cross the LOS and either disappear from view or come into view from the RIP.

Main Recreation Season (MRS); That part of the summer season between the beginning of the Memorial Day weekend through to the end of the Labor Day weekend. On average this season is 101 days long.

Motorized Tour Boat (MTB); Jetboats operated as a commercial river touring activity.

MTB Operator; The person that navigates the MTB craft; the pilot.

MTB Owner/Operator; The person or corporation that owns, operates, and has overall control of MTB fleet operations.

MTB trip; A group of individual MTB craft on a single itinerary schedule; typically MTB trips include 1-7 craft on the Hellgate Study Reach and 1-2 craft on the Gold Hill Study Reach.

MTB trip itinerary; A specific route and sequence of on-river activities of an individual MTB trip. On the Hellgate Study Reach this includes Dinner, Brunch, Scenic, and Whitewater trips on the Gold Hill Study Reach this includes the 1-hour, 2-hour, and the Dinner trips.

MTB trip itinerary schedule; The specific time of departure and return and times of on-trip activities of a specific MTB trip itinerary; on the Hellgate Study Reach this includes the AM Whitewater, PM Whitewater, AM Scenic, PM Scenic, and Dinner trips.

MTB trip schedule; The general departure and return MTB trip schedule for all MTB trips of any given day or portion of the season etc.

MTB run; The progression of the lead MTB through a specific SOC.

Mutual Occupation (MO); Situations in which MTB/FC encounters occur at less than safe craft separation distance even when the best MTB operator skills and best judgement is used; inadvertent MOs. In this BS/C Study MOs are incidents in which accidents are possible. By definition MOs can only occur in SOCs (see Overt Mutual Occupation).

Off-Plane; Low speed JB operational mode in which the hull is fully settled in the water and the draft is moderate (about 1.5 ft. for MTBs), and the draft is set only by the hull displacement and weight of the craft. This conditions exists when the JB is either stopped, drifting, or moving at slow speeds.

On-Plane; High speed JB operational mode in which the hull is planing on the water surface and the hull draft is minimum, about 0.75 ft.

On-Step; A JB operational mode referring to the transition between on-plane and off-plane operational modes when the hull's angle of attack to the water is at a maximum and water depth requirements are at a maximum (about 3 ft.).

Operational Mode; Refers to the speed and hull attitude of JBs. In varying operational modes JBs have different drafts and different water depth requirements (See "Off-Plane", "On-Plane", and "On-Step").

Overt Mutual Occupation (Overt MO); Incidents where MTB/FC encounters occur at less than safe craft separation distances when the MO could have been avoided by better MTB operator skill, more prudent judgement, or more safety conscience decisions. These can occur in SOCs as well in all other portions of the study reaches.

Physical Stopping Distance (PSD); The distance required for a MTB to completely stop or to reach a drifting attitude from on-plane operational speeds while stopping in a straight line.

Potential Accident or Hazard; In this BS/C Study this refers to MTB/FC encounters where accidents are possible outcomes (see "Accident"). By definition they occur in MOs (see "Mutual Occupation").

Private Jetboat (Pvt-JB); A JB used for non-commercial purposes most often angling and high performance river recreational powerboating.

Probability of Mutual Occupation (PMO); The probability that MTBs and FC will inadvertently co-occupy portions of a SOC. It combines the PSRs of the SOC with the probability that FC are in the SOC when the MTB arrives, and uses the assumptions of best MTB operator skill and most prudent judgement.

Probability of Not Being Seen (PNS); The probability that all FC that occupy a SOC are not visible to the MTB operator at the SOC RIP.

Probability of Rapid Occupation (PRO); The probability that at least one FC will be occupying a specific SOC on a specific MTB run. It is a function of the FC use level, the time of day, the FC Use Distribution Model, and the length of the SOC.

Probability of Safety Risk (PSR); The probability that a JB/MTB will overtake a FC in a SOC if the JB/MTB initiate the run when the FC is unseen.

Rapid; A hydraulic constriction and/or gradient shift that results in hydraulic turbulence and head loss where the channel and bed features that control the turbulence result from processes that are dominated by bedrock elements of the bed and/or bank, or material so large that bed material only reposition or move short distances and then only during extremely rare events (See "Riffle").

Recreational Resources; Recreational areas or geographic units within which any specific type of recreation is undertaken; ie. the Rogue River, Crater Lake NP. Also a specific set of natural or man made features that form the basis of a recreational activity; ie. whitewater hydraulics, anadromous fish runs, lakes, reservoirs, bike trails, etc.

Recreational Resource Conflicts; Circumstances that create a degradation in the recreational resource values of one or more users or use activity types as a result of the activities or activity pattern of other use activity types.

Recreational Resource Values; The sum total, and all constituent parts, of the valued aspects of any given recreational activity including but not limited to; flow level, weather, scenic quality, freedom of movement, water temperature and quality, etc.

Riffle; A hydraulic constriction in a stream channel caused by the accumulation of bed-transported sediment. The shape, dimensions, gradient, and water depth of riffles and often their locations, are a result of channel processes dominated by the streamflow and sediment regimes of the stream (See "Rapid").

River Left, Right, Center (RL, RR, RC); The general directional references to on-river features, always with respect to a downstream view.

River Mile (RM); Milage along a study reach as measured along the river centerline from the upstream end of the study reach.

Run Initiation Point (RIP); The location at which the final decision must be made by the MTB operator to stop or run a SOC. It is located along the MTB route, a distance prior to the entrance set-down threshold equal to the assumed MTB SSD. Once past the RIP it is assumed not to be possible to safely stop an on-plane MTB before passing the entrance set-down threshold. (See "Safe Stopping Distance")

Safe Craft Separation (distance, threshold); This is the distance between a JB and other non-powered craft that is required to maintain safe conditions in a variety of channel/hydraulic conditions. As turbulence increases and FC have less control over float directions the safe craft separation distances would increase.

Safe Stopping Distance (SSD); The distance required to safely stop a MTB under a variety of situation scenarios. The SSDs are based on the MTB PSD, hull length, operator position, safe craft separation thresholds, operational direction, and various LOS considerations. SSDs are used to determine the usability of set-down areas and to set RIP and ST locations relative to set-down threshold locations.

Safety Risk; General; the probability (i.e. risk) of an adverse safety related outcome ("safety" issues vary). Specific; in this BS/C Study it is defined as circumstances that could lead to accidents that could result in death, injury, and/or equipment damage when even the best operator skill and most prudent judgement are used. It refers only to the potential for inadvertent mutual occupation of portions of SOCs resulting from the interactions of motorized and non-motorized recreational activities.

Safety Risk-Related Conflict; In this BS/C Study, these are conflicts that are related to safety risks; those interactions between motorized and non-motorizeded activities which do not directly result in safety risks but can lead to safety risk situations. Specifically these conflicts refer to the modeled probability of wait incidents at SOCs which occur when avoiding overt MOs.

Safety Risk/Conflict Model (SR/C Model); The spreadsheet model that is used to develop measures of safety risk and conflict for various recreation conditions and recreation management scenarios. It incorporates the SOC Assessments, the FC Use Distribution Model, and MTB trip itinerary schedules. (See "Wait-Related Conflict", and "Conflict".)

Safety Risk Parameters; The parameters that describe the various safety risk attributes of specific SOCs that are based on the physical characteristics of the SOCs and the craft use patterns (PSR, PNS, PMO, and ISR)

Safety Threshold (ST); This is the far end of the SOC with respect to the direction of MTB travel. It is set by the set-down threshold location, the SSD of the MTB, and any additional FC float-in issues that may be present during upstream MTB operations.

Set-down Areas; Portions of the channel with sufficient depth over an adequate width and length to allow JB/MTBs to safely come off-plane and to stop or stop to drift.

Set-down Threshold; That location in the channel where adequate depths define the upstream or downstream boundaries of the set-down area.

Scenic Section; That portion of the Hellgate Study Reach between the 6th St. Bridge in Grants Pass (RM 0.0) to Zigzag Creek (RM 19.7).

Site of Concern (SOC); Specific portions of the study reaches in which physical conditions create reduced JB operational options that could result in accidents or unacceptably close encounters even when best operator skill and most prudent judgement are used.

Site of Concern Assessment (SOC Assessment); The evaluation of each SOC/scenario undertaken to estimate the "inherent safety risk" associated with MTB and FC uses and the relationship between FC use levels and safety risks and conflict.

Site of Concern/Scenario (SOC/scenario); The BS/C consideration of each SOC under four sets of conditions: upstream v. downstream operating MTBs, and high v. low flow conditions.

Study Area; The reaches of the Rogue River addressed in the BS/C Study; includes the Hellgate Study Reach and the Gold Hill Study Reach.

Study Reach; Separate portions of the Rogue River BS/C Study Area with distinct recreational activity patterns, MTB use and craft characteristics, and recreation management institutions; Hellgate Study Reach and the Gold Hill Study Reach.

Tailwater; The run-out hydraulics at the bottom of riffles and rapids that are often characterized by a constricted and centralized body of downstream flowing water, a compression wave train, bank eddies on one or both sides of the main current, and sometimes confused hydraulics.

Tongue; The entry portion of riffles and rapids where the water is increasing in speed and the surface is relatively smooth and glassy, which leads from the upstream pool or quiet water area to the riffle/rapid hydraulics. The tongue is bordered by bank dominated hydraulics that progressively impinge on the tongue and the tongue gradually narrows downstream to a point.

Unit Use Curves (UUCs); Time of day FC use distribution at each of the 22 locations in the FC Use Distribution Model. The curves can be modified in magnitude to reflect different FC use levels and modified in shape to reflect different use patterns or facility capacity limited and or user dislocation.

View Field; That portion of SOCs that are observable by the MTB operator from the SOC RIP. It is limited by the LOS and the LOS threshold.

Wait-Related Conflict; The calculated MTB wait circumstances at SOCs as determined by the probabilities that FC are present at the moment of MTB arrival, that the FC are seen by the JB/MTB operator, and that the MTB waits for the SOC to clear of FC before proceeding. It is composed of the frequency and duration of MTB waits. It is a surrogate measure of accommodation at SOCs by all users that are necessary to avoid overt MOs. It is used as a measure for "Safety Risk-Related Conflict".

Whitewater Section; That portion of the Hellgate Study Reach between Zigzag Creek (RM 19.7) and the Grave Creek Access Ramp (RM 33.3).

INTERNATIONAL SCALE OF RIVER DIFFICULTY

CLASS I: Fast moving water with riffles and small waves. Few obstruction, all obvious and easily missed with little training. Risk to swimmers is slight; self-rescue is easy. (Easy)

CLASS II: Straightforward rapids with wide, clear channels which are evident without scouting. Occasional maneuvering may be required, but rocks and medium sized waves are easily missed by trained paddlers. Swimmers are seldom injured and group assistance, while helpful, is seldom needed. (Novice)

CLASS III: Rapids with moderate, irregular waves which may be difficult to avoid and which can swamp an open canoe. Complex maneuvers in fast current and good boat control in tight passages or around ledges are often required; large waves or strainers may be present but are easily avoided. Strong eddies and powerful currents effects and be found, particularly on large-volume rivers. Scouting is advisable for inexperienced parties. Injuries while swimming are rare; self-rescue in usually easy but group assistance may be required to avoid long swims. (Intermediate)

CLASS IV: Intense, powerful but predictable rapids requiring precise boat handling in turbulent water. Depending on the character of the river, it may feature large, unavoidable waves and holes or constricted passages demanding fast maneuvers under pressure. A fast, reliable eddy turn may be needed to initiate maneuvers, scout rapids, or rest. Rapids may require "must" moves above dangerous hazards. Scouting is necessary the first time down. Risk of injury to swimmers in moderate to high, and water conditions may make self-rescue difficult. Group assistance for rescue is often essential but requires practiced skills. A strong eskimo roll is highly recommended. (Advanced)

CLASS V: Extremely long, obstructed, or very violent rapids which expose a paddler to above average endangerment. Drops may contain large, unavoidable waves and holes or steep, congested chutes with complex, demanding routes. Rapids may continue for long distances between pools, demanding a high level of fitness. What eddies exist may be small, turbulent, or difficult to reach. At the high end of the scale, several of these factors may be combined. Scouting in mandatory but often difficult. Swims are dangerous, and rescue is difficult even for experts. A very reliable eskimo roll, proper equipment, extensive experience, and practiced rescue skills are essential for survival. (Expert)

CLASS VI: One grade more difficult than Class V. These runs often exemplify the extremes of difficulty, unpredictability and danger. The consequences of errors are very severe and rescue may be impossible. For teams of experts only, at favorable water levels, after close personal inspection and taking all precautions. This class does not represent drops thought to be unrunnable, but may include rapids which are only occasionally run. (Extreme)

Notes: Source; American Whitewater Affiliation (Revised, 1989).
References to boater skills vary dramatically with craft type.
Application and description of the classes may vary from region to region.
(-) or (+) may be attached to indicate conditions outside the central theme of the classification descriptions.

STUDY PARTICIPANTS

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